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# NUCLEAR SCIENCE ABSTRACTS

## CHEMISTRY

### Analytical Chemistry

*Refer also to abstracts 1397, 1438, and 1659.*

**1237** (AE-237) MICROANALYSIS OF FLUORINE CONTAMINATION AND ITS DEPTH DISTRIBUTION IN ZIRCALOY BY THE USE OF A CHARGED PARTICLE NUCLEAR REACTION. Moeller, E.; Starfelt, N. (Aktiebolaget Atomenergi, Stockholm (Sweden)). July 1966. 16p. Dep. mn.

Fluorine contamination on and below the surface of Zircaloy was studied by means of proton irradiation using a Van de Graaff accelerator and the detection of prompt gamma radiation from the $^{19}F(p,\alpha\gamma)^{16}O$ reaction. Formulas for deriving depth distributions of impurities from the measured counting rates were derived. The influence of energy straggling on the depth resolution was studied. Both the total amount and the depth distribution were measured in samples, which had undergone different treatments. Because of the high yield from the reaction used, a quantity of fluorine less than 0.01 $\mu g/cm^2$ can be detected by this method. (auth)

**1238** (AECL-2596) ANALYTICAL PROCEDURES (1966) FOR THE HEAVY WATER AND HELIUM SYSTEMS OF THE NRX AND NRU REACTORS. PARTS I, II, AND III. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). June 1966. 150p. Dep. mn. AECL $2.50.

Analytical methods presently being used by the control laboratories for analysis of the heavy water and helium systems of the NRX and NRU reactors are outlined. The methods are divided into three parts: isotopic analysis of heavy water; identification and measurement of the ionic impurities in heavy water; and analysis of gaseous impurities in the helium systems and dissolved gases in the heavy water. Some of the methods, particularly a few of the ionic procedures, are not used routinely but are readily available for special experiments. (P.C.H.)

**1239** (AECL-2631) GRAPHS AND TABLES OF THE ISOTOPIC COMPOSITION OF PLUTONIUM PRODUCED IN CANADIAN $D_2O$ COOLED AND MODERATED REACTORS. Halsall, M. J. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Oct. 1966. 28p. (CRRP-1245). Dep. mn. AECL $1.00.

The isotopic composition of natural uranium fuel irradiated to 10,000 MWd/t has been calculated at intervals of 500 MWd/t for three reactors – NPD, CANDU – PHW and Pickering. Three sets of results are tabulated for each reactor. These correspond to operation at the design lattice pitch and also at pitches chosen to reduce and increase the volume of moderator by 20%. Only the normal lattice pitch results are given graphically as the differences with changing pitch tend to be rather small. (auth)

**1240** (CEA-R-2969) DOSAGE DU FER DANS LE PLUTONIUM PAR EXTRACTION DU COMPLEXE FeII: BATHOPHENANTHROLINE. (Determination of Iron in Plutonium by Extraction of the Fe(II): Bathophenanthroline Complex). Pichotin, Bernard; Chasseur, Philippe (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). June 1966. 14p. Dep. mn.

A method is described for determining micro quantities of iron in plutonium; by extraction of the iron (II) complex with bathophenanthroline (4,7-diphenyl – 1,10-phenanthroline) using hexanol. The reagent was applied to the determination of amounts of iron ranging from 1 to 10 $\mu g$ in 20 ml of solvent. The determination is made by spectrophotometry at 530 m$\mu$. Other cations present do not interfere. (auth)

**1241** (CEA-R-3033) ANALYSE DE MELANGES DE RADIONUCLEIDES PAR UN DISPOSITIF SIMPLE DE COINCIDENCES $\alpha-\gamma$ ET $\beta-\gamma$. (Analysis of Radionuclide Mixtures by $\alpha-\gamma$ and $\beta-\gamma$ Coincidences Using a Simple Device). Pottier, Raymond; Berger, Rene (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). June 1966. 44p. In French. Dep. mn.

A procedure is described for the qualitative and quantitative spectrographic analysis of radioactive sources containing two alpha-gamma emitters having the same alpha energy or two beta-gamma emitters having the same gamma energy. The main apparatus is a multichannel pulse-height analyzer including a coincidence circuit. The principle of the method, the synoptic scheme, the electronic device, the type of sources, and the precautions to be taken or the corrections to take into account are reported. The results obtained in solving the three following problems are discussed as examples of applications of the method: analysis for $^{241}Am$ in alpha-gamma sources containing $^{238}Pu$; analysis for $^{237}Np$ in beta-gamma sources containing $^{239}Pu$; and analysis for $^{106}Ru$-$^{106}Rh$ in beta-gamma sources containing $^{95}Zr$-$^{95}Nb$. (auth)

**1242** (EUR-3073.i) DETERMINAZIONE DI TRACCE DI BORO NEI MATERIALI UTILIZZATI NELLA FILIERA ORGEL: MONOCARBURO DI URANIO, SAP, TERFENILE. (Determination of Boron Traces in the Materials Used in the Orgel Reactors: Uranium Monocarbide, SAP, Terphenyl). Serrini, G.; Wehking, W. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 24p. Dep. mn.

Trace determination of boron in uranium monocarbide, SAP materials, and terphenyls by chemical methods is described. The detection limit obtained was 0.05 ppM for uranium monocarbide and terphenyls, and 0.2 ppM for SAP materials. (auth)

**1243** (JAERI-1112) PREPARATION OF JAERI $U_3O_8$ SPECTROCHEMICAL STANDARDS. Motojima, Kenji (Japan Atomic Energy Research Inst., Tokyo). May 1966. 44p. (In Japanese). Dep. mn.

A series of $U_3O_8$ standard samples for spectrochemical analysis were prepared. A matrix oxide was obtained by thermal decomposition of high-purity uranyl acetate. Known amounts of 16 elements (Ag, Al, B, Ca, Cd, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Ni, P, and Si) in solutions were added to the matrix oxide. The oxide to which these impurities were added was diluted with the matrix for preparing the standard series. A homogeneity test was preformed on the prepared standards by spectrochemical method. Co-operative chemical and spectrochemical analyses were carried out under the auspices of the Advisory Committee on Analytical Chemistry of Nuclear Fuels and Reactor Materials of JAERI. Analytical results of 12 elements, statistically treated, are given in this report. Determinations of boron by isotope dilution mass spectrometry and the curcumin spectrophotometric method are also reported in an appendix. (auth)

**1244** (LA-3549) THE X-RAY FLUORESCENCE SPECTROMETRIC DETERMINATION OF THULIUM IN PLUTONIUM-THULIUM ALLOYS. Hurley, R. G.; Hakkila, E. A.; Waterbury, G. R. (Los Alamos Scientific Lab., N. Mex.). July 1, 1966. Contract W-7405-eng-36. 17p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Thulium is determined in plutonium by measuring the intensity of the thulium $L\alpha_1$ x ray, correcting for the blank intensity, and comparing the corrected intensity with intensities measured for solutions containing known thulium concentrations. To prepare the solution for x-ray fluorescence measurement, duplicate 1-g samples are dissolved in hydrochloric acid and fumed repeatedly with nitric acid to eliminate chloride ion. Each solution is diluted to 5.00 ml with distilled water and nitric acid to provide a final acidity of 6.3M. This solution is irradiated in a nylon sample cell using a tungsten-target x-ray tube. The relative standard deviation

of the method varies from 25% for 200 ppM of thulium to 1% for thulium concentrations greater than 1%. Only dysprosium, samarium, gadolinium, terbium, and iron interfere seriously with this method. (auth)

**1245** (LA-3550) THE SEPARATION OF RHENIUM FROM COPPER, MOLYDENUM, AND TUNGSTEN AND ITS SPECTROPHOTOMETRIC DETERMINATION. Landrum, J. H.; Henicksman, A. L. (Los Alamos Scientific Lab. N. Mex.). June 1966. Contract W-7405-eng-36. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Existing methods for the separation and spectrophotometric determination of rhenium were modified, applied, and critically evaluated for the determination of rhenium in metal samples containing large amounts of copper, molybdenum, and tungsten. In the method as developed, the rhenium was extracted into chloroform as tetraphenylarsonium perrhenate, following which a color was developed with furil dioxime and measured spectrophotometrically. Many of the ions reported to interfere in the original color method are eliminated by the chloroform extraction. Copper, molybdenum, tungsten, and hydrofluoric acid may be present in large amounts, and nitrate ion can be tolerated to a lesser degree. In the raffinate from the chloroform extraction, molybdenum and tungsten were analyzed by an existing spectrophotometric procedure. Molybdenum was selectively extracted into pentyl acetate as the dithiol complex from a solution 6N in hydrochloric acid. The absorbance of the complex was measured in the organic solution. In the water phase from this extraction, tungsten was isolated by adjusting the acidity to 9N and reducing the tungsten with titanous chloride. The colored complex of tungsten with dithiol was also extracted into pentyl acetate and measured directly. The analysis of known mixtures of the three metals, containing, in addition, large amounts of copper, showed recoveries of at least 99% for each, and each had a calculated standard deviation for a single determination of 1%. (auth)

**1246** (LA-3551) THE SPECTROPHOTOMETRIC DETERMINATION OF TRACE AMOUNTS OF URANIUM IN HIGH-PURITY PLUTONIUM METAL. Gardner, Ross D.; Ashley, William H. (Los Alamos Scientific Lab., N. Mex.). June 1966. Contract W-7405-eng-36. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Trace amounts of uranium in high-purity plutonium metal are determined spectrophotometrically with Arsenazo after an anion exchange separation in hydrochloric acid. In the procedure described, dissolution of the metal sample in hydrochloric acid results in a solution in which both uranium and plutonium are present in the (III) oxidation state. The addition of a small amount of bromine water oxidizes all of the uranium to the (VI) state, and any excess oxidizes plutonium to (IV). When this solution is passed through a column of Dowex-1 resin, the uranium(VI) and plutonium (IV) are adsorbed, but nearly all of the plutonium, as plutonium(III), remains in solution and is washed through the column with concentrated hydrochloric acid. The adsorbed uranium and plutonium are readily eluted from the resin with dilute hydrochloric acid. When hydroxylamine is added to the eluate, the small amount of plutonium remaining is selectively reduced to plutonium(III), and the passage of the solution through the column a second time results in a quantitative separation of the uranium. The lower limit of detection of the method is 1 ppM, and the precision in the 0- to 10-ppM range is ±1 ppM. The precision in the 10- to 100-ppM range is approximately ±3 ppM. (auth)

**1247** (LA-3552) THE TITRIMETRIC DETERMINATION OF COPPER IN COPPER–BORON CARBIDE MIXTURES. Hues, Alvin D.; Ashley, William H. (Los Alamos Scientific Lab., N. Mex.). May 1966. Contract W-7405-eng-36. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A titrimetric method was modified and applied to the determination of copper in copper–boron carbide mixtures. The copper in the sample is dissolved with nitric acid and the resulting solution buffered with ammonium acetate. The copper is titrated potentiometrically, in the presence of the undissolved boron carbide, with a 0.05 M solution of EDTA, using a platinum-tungsten electrode system. The copper found in 30 simulated samples, prepared to contain known amounts of boron carbide and copper over the range of 50 to 100% copper, averaged 99.98% of the amount added, with a relative standard deviation of 0.04% for a single determination. The time required for an analysis is less than one-half that required by the conventional electrolytic method. (auth)

**1248** (MLM-1349) SURVEY OF SOURCES OF IONIUM (THORIUM-230). Figgins, P. E.; Kirby, H. W. (Mound Lab., Miamisburg, Ohio). Aug. 1, 1966. Contract AT(33-1)-Gen-53. 17p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Data for six sources with ionium isotopic concentrations of 1% or higher are given in order of descending isotopic concentration. On the basis of isotopic concentration and potential, the best source is the St. Louis residues. A second choice ionium source depends upon a number of factors such as the quantity and isotopic concentration desired, size, type, and location of processing facilities, and the economics of recovery processes. Each alternate source may possess slight advantages over the St. Louis residues in a particular situation. It is concluded, however, that the best source of ionium was, and still is, the St. Louis Airport residue. (auth)

**1249** (NLCO-987) APPLICATION OF ATOMIC ABSORPTION TO THE DETERMINATION OF Al, Fe, AND Ni IN THE SAME URANIUM-BASE SAMPLE. Jursik, M. L. (National Lead Co. of Ohio, Cincinnati). Sept. 19, 1966. Contract AT(30-i)-1156. 15p. (CONF-661023-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 14th Anachem Conference, Detroit, Mich.

Atomic absorption spectrophotometry was applied to the determination of Al, Fe, and Ni in a single sample of U metal. The technique is rapid and is as accurate and precise as the colorimetric procedures for these elements. The analyses are performed by first dissolving the U sample in nitric acid. The U is then extracted into a tributyl phosphate–carbon tetrachloride solution. The aqueous phase, which contains the Al, Fe, and Ni, is aspirated into the flame. Aluminum in the range of 600 to 1000 ppM, U basis, is determined with a high-temperature burner and a nitrous oxide–acetylene flame. Iron in the range of 100 to 400 ppM and Ni in the range of 50 to 200 ppM are determined with the conventional slot burner and an air–acetylene flame. (auth)

**1250** (PG-Report-720) A POTENTIOMETRIC, HIGH PRECISION, ASSAY METHOD FOR THE DETERMINATION OF URANIUM METAL. (United Kingdom Atomic Energy Authority, Springfields (England). Production Group). 1966. 14p. BIS $0.50; HMSO 2s. 6d.

A portion of the sample is dissolved in orthophosphoric acid. Lower valency states of impurities and $U^{3+}$ are oxidized by aeration and an excess of potassium dichromate over that required to oxidize the tetravalent uranium is added. The excess potassium dichromate is then titrated potentiometrically using ferrous ammonium sulfate solution. For uranium metal of 99.98% purity the bias does not exceed ±0.005%. The standard deviation at the 99.98% level is ±0.0045%. (auth)

**1251** (PG-Report-737) APPLICATIONS OF ABSORPTION SPECTROPHOTOMETRY (INFRARED AND VISIBLE) TO THE DETERMINATION OF IMPURITIES IN TRIBUTYL PHOSPHATE AND DEGRADED TRIBUTYL PHOSPHATE/KEROSENE MIXTURES. Hughes, E. (United Kingdom Atomic Energy Authority, Sellafield (England). Production Group). 1966. 18p. BIS $0.50. HMSO 2s. 6d.

A review is presented of the development of a number of methods for the analysis of raw tributyl phosphate and degraded process solvents. The work is based on absorption spectrometric techniques in the infrared and visible regions, with or without preliminary chemical separation. Each of these methods was applied for a number of years to the routine analysis of process solvent and samples arising from various research projects. The methods enabled quantitative studies of the effect of solvent degradation on process performance to be made. (auth)

**1252** (UCRL-14957) AUTOMATION IN ANALYTICAL CHEMISTRY. Frazer, Jack W.; Anderson, Roger E. (California Univ., Livermore. Lawrence Radiation Lab.). June 16, 1966. Contract W-7405-eng-48. 11p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The reasons for automation of an analytical chemistry laboratory and the progress to date on using a control computer in analytical procedures are discussed. The analytical techniques considered are gas chromatography; mass spectrometry; simultaneous carbon, hydrogen, and nitrogen analyses; surface-area determinations; vacuum-fusion analyses; and various other gas-transfer determinations. (D.H.M.)

**1253** (NP-tr-1421) ISOTOPE ANALYSIS OF IRON. Rolle, W.; Zahn, H. Translated by R. R. Inston (Atomic Energy Research Establishment, Harwell, Eng.), from Abhandl. Deut. Akad. Wiss. Berlin, Kl. Chem., Geol., Biol., No. 7, 359-62(1964). 8p. Dep. mn. JCL $1.10 fs, $0.80 mf.

It was found that the $FeI^+$ ions obtained from ferrous iodide vapors can be used for an isotopic analysis of iron enriched in an electromagnetic separator. Preparation of the sample is described. Since the iodine used is monoisotopic, the intensity of the mass peak ($FeI^+$) in mass spectroscopy is a direct measure of the relative abundances of the iron isotopes. It was concluded that the smallest quantity of iron sufficient for an accurate analysis is 1 mg, that is, ~5.5 mg of ferrous iodide. (M.C.G.)

**1254** (ORNL-tr-1385) A NOTE ON THE COMPOSITION OF CERIUM TTA COMPLEXES AND THE OXIDATION OF CERIUM (III) ION. Yoshida, Hiroyuki; Nagai, Hitoshi; Onishi, Hiroshi.

Translated for Oak Ridge National Lab., Tenn., from Bunseki Kagaku, 15: 513-16(1966). 10p. Dep. mn. JCL $1.10 fs, $0.80 mf.

Spectrophotometric methods for the determination of cerium with thenoyltrifluoroacetone (TTA) were developed by Khopkar and De, and Onishi and Banks. The composition of the cerium–TTA complex extracted with xylene from 1N sulfuric acid solution containing bromate (the conditions of Onishi and Banks) is probably $CeT_4$, where HT is the enol form of TTA. The extraction constant of this system was calculated to be $2 \times 10^3$. An attempt to obtain a precipitate of the complex under similar conditions was not successful. The composition of the cerium–TTA complex extracted under Khopkar and De's conditions could not be determined, because the plot of log $D_{Ce}$ versus log [TTA] was not a straight line ($D_{Ce}$: distribution ratio of cerium). Apparent molar absorptivities for cerium (IV) in benzene were $4.1 \times 10^3$ and $3.6 \times 10^3$ at 440 and 450 mμ, respectively. Although Khopkar and De suggested the oxidation of cerium (III) by bromate and dichromate in slightly acid solution, this oxidation is incomplete. The oxidation of cerium (III) (10 to 20 mg) is almost complete when 10 ml of a solution that is 1N in sulfuric acid and 0.3M in sodium bromate is heated at 70°C for 1 hour. (auth)

**1255** NEW METHOD OF VOLUMETRIC ANALYSIS OF CERIUM. Cheng, Ta-chung. Hua Hsueh Shih Chieh, No. 12, 559-60(Dec. 1965). (In Chinese).

With the ammonium super sulfate method of cerium determination the acidity must be controlled. If the solution is too highly acid, the hydroperoxide created will cause the cerium to be reduced; if it is not sufficiently acid, cerium sulfate in the alkaline form may be easily created. In this paper the author proposes a new superchloric acid method to overcome the above defects. A superchloric acid method is proposed for determination of cerium that overcomes the difficulties of the critical control of acidity necessary in the ammonium super sulfate method. (TCO)

**1256** PHOTOMETRIC DETERMINATION OF THE MICRO-QUANTITIES OF RARE EARTH ELEMENTS AND THORIUM IN ORES. Yu, Kuo-su. Hua Hsueh Shih Chieh, 18: 565-8(1964). (In Chinese).

A spectrophotometric method for the total rare earths and Th is based on the color formed with arsenazo I (I) and arsenazo III (II), respectively. The sample solutioning consists of fusing a 0.5 to 1 g sample in a Ni crucible with 4 g each of NaOH and $Na_2O_2$ for 3 to 5 min. The melt is leached with hot water, and any insoluble residue is dissolved in HCl and added to the water leach. Two grams of $NH_4Cl$ are added to the resulting solution, the solution is diluted, and an amount of ammonium hydroxide sufficient to precipitate the hydroxides of Al and Fe plus a 10 ml excess is added. After coagulation, the residue is removed by filtration, washed, and redissolved in HCl. The pH of the filtrate is adjusted to 1 to 3, and the rare earths and Th are precipitated by the addition of 5 g of oxalic acid and ten milligrams of Ca. The filtrate is then heated on a water bath for 2 hrs and allowed to stand overnight. The precipitated Th and rare earths are filtered off, washed, and calcined at 500 to 550°C for 30 min. The calcined residue is then dissolved in 3 ml of concentrated HCl and the solution diluted to 10 ml. For the Th determination, an aliquot of the solution, 20 ml of 4N HCl, 2 ml of 4% solution of oxalic acid, and 2 ml of 0.2% solution of II are mixed together and diluted to a volume of 50 ml with 4N HCl. The photometric measurement is made in a 2 cm cuvette using a photometer with a red filter. For determination of total rare earths another aliquot of the solution is mixed with 1 ml of 5% tartaric acid, 3 ml of 7.5% sulfosalicylic acid, and ammonium hydroxide (1 : 1) until the appearance of the yellow color. The yellow color is then removed with 1N HCl. Two milliliters of a 0.1% solution of I and 10 ml of 20% urotropin solution is added, and the resulting solution is diluted to 25 ml. The photometric measurement is made in a 2 cm cuvette with a yellow filter. (JPRS)

**1257** A SIMPLE METHOD FOR COMBUSTING TISSUES FOR CHLORINE-$^{36}$Cl ANALYSIS. Smith, Grant N. (Dow Chemical Co., Midland, Mich.). Anal. Biochem., 17: 24-37(Oct. 1966)

A simple apparatus and method is described for the combustion of biological samples containing $^{36}$Cl-labeled compounds. The samples are combusted in a mixture of $HNO_3$ and $H_2SO_4$, and the liberated chloride is trapped as AgCl, which can be dissolved and counted in a scintillation counting system. With these techniques it is possible to detect Cl-labeled compounds with specific activity of 0.02 mmole in concentrations of 0.02 to 0.05 ppm in tissue. (auth)

**1258** AN IMPROVED METHOD FOR THE DETERMINATION OF DEUTERIUM IN ORGANIC COMPOUNDS. Eisenberg, Frank Jr. (Dept. of Health, Education, and Welfare, Bethesda, Md.). Anal. Biochem., 17: 93-9(Oct. 1966).

A method for the determination of $D_2$ in organic compounds was developed, which is based on the oxidation of organic $D_2$ to DCl by $HgCl_2$ with subsequent reduction of DCl by Zn to release $D_2$ for mass spectrophotometric analysis. The method is applicable to various organic compounds, including aliphatic, aromatic, and amino acids and gives quantitative results in the range of 0.02 to 5 at. % excess $D_2$. (auth)

**1259** PYRIDINE NUCLEOTIDES. II. RADIOMETRIC DETERMINATION OF MINUTE QUANTITIES OF TRIPHOSPHOPYRIDINE NUCLEOTIDES. Serif, George S.; Schmotzer, Linda; Butcher, Fred R. (Ohio State Univ., Columbus). Anal. Biochem., 17: 125-34(Oct. 1966).

An assay is described for triphosphopyridine nucleotides ($TPN^+$ and TPNH) with sample amounts as low as $10^{-13}$ mole. The assay utilizes enzymic cycling of $TPN^+$ and TPNH by l-glutamate dehydrogenase and glucose-6-phosphate dehydrogenase to convert (1-$^{14}$C)-α-ketoglutarate to l-glutamatem, which is subsequently decarboxylated to $^{14}CO_2$ and counted as a measure of $TPN^+$ and TPNH concentration. (auth)

**1260** DETERMINATION OF THE SPECIFIC ACTIVITY OF LABELED LACTATE IN BIOLOGICAL FLUIDS BY LIQUID SCINTILLATION. Jones, G. B.; Buckley, R. A. (Commonwealth Scientific and Industrial Research Organization, Adelaide). Anal. Biochem., 17: 162-70(Oct. 1966).

A procedure is described for the convenient and accurate determination of the specific activity of $^{14}$C-labeled lactate present in biological fluids or tissue homogenates by liquid scintillation counting. The lactic acid is oxidized to acetaldehyde, which is condensed with dimedone to produce, in high yield, ethylidine bismethone, which is easily purified and readily soluble in toluene phosphor. A correction for quenching must be applied. The procedure is specific to lactate, but is applicable to measuring the radioactivity associated with only the 2- or 3-carbon atom of lactate. In studies in which the relationship between lactate and glucose is involved, uniformly labeled glucose must be employed. (auth)

**1261** DETECTION OF OXYGEN IN METALS, PARTICULARLY IN STEEL, BY ACTIVATION ANALYSIS WITH 14.5-MeV NEUTRONS. Schramel, P.; Muenzer, H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 266-71(1966). (In German).

A method for the activation analysis of $O_2$ in metals, particularly steel, is outlined. The interfering reactions and corrections that must be made in compensation are given. The method is valid to $O_2$ contents of 25 ppM. The relative error at $O_2$ concentrations under 20 ppM is approximately 15%. The method is suitable for routine measurements. (J.S.R.)

**1262** ACTIVATION ANALYSIS FOR TITANIUM AND NIOBIUM WITH FAST NEUTRONS. Athavale, V. T.; Desai, H. B.; Gangadharan, S.; Pendharkar, M. S.; Das, M. Sankar (Atomic Energy Establishment, Trombay, India). Analyst, 91: 638-46 (Oct. 1966).

Fast-neutron activation methods were developed for determining titanium and niobium. Scandium-47 formed by the (n,p) reaction on titanium-47 and yttrium-90 formed by the (n,α) reaction on niobium-93 were used for determining these elements. Irradiations were carried out in the swimming-pool reactor "Aspara" at the Atomic Energy Establishment Trombay, at a fission flux of $3 \times 10^{11}$ n per cm$^2$ per sec. Radiochemical procedures were developed for the isolation of scandium and yttrium from the irradiated samples. The methods were applied to the determination of titanium in stabilized steels, and the standard rocks G-1 and W-1 and of niobium in stabilized steels. Advantages and limitations of the methods are discussed. (auth)

**1263** MICRODETERMINATION OF IODIDE IONS BY RADIOACTIVE PRECIPITATION EXCHANGE. Banyai, E.; Szabadvary, F. (Technische Univ., Budapest). Mikrochim. Acta, No. 4-5, 601-5(1966). (In German).

If iodide ions are shaken with a $HgI_2$ precipitate, soluble iodomercurate results. The activity of the solution is proportional, within certain concentration limits, to the amount of iodide. (auth)

**1264** NEUTRON ACTIVATION ANALYSIS OF IMPURITIES, COBALT AND NICKEL IN URANIUM COMPOUNDS OF NUCLEAR PURITY. Oerdoegh, M.; Csajka, M. (Zentralforschungsinstitut fuer Physik, Budapest). Mikrochim. Acta, No. 4-5, 606-11(1966). (In German).

A method was developed for determining nickel and cobalt in uranium compounds of nuclear purity. The bulk of the uranium is removed by paper chromatography prior to the irradiation. Cobalt and nickel are determined with the aid of the isotopes $^{60}$Co and $^{58}$Ni respectively. Gamma spectrometry or the complement subtraction procedure was used to separate the two cobalt isotopes. (auth)

**1265** VOLUMETRIC-ANALYSIS DETERMINATION OF MERCAPTOBENZTHIAZOL IN THE HEAT EXCHANGER OF A REACTOR. Kiss, Sandor A. Mikrochim. Acta, No. 4-5, 612-14(1966). (In German).

A volumetric method was developed for determining slight amounts of mercapto-benzothiazol in the cooling liquid of reactors. It is titrated in an ammoniacal medium with ammoniacal silver nitrate. The mercapto-benzothiazol yields a colorless flocculent precipitate with silver ions. The endpoint of the titration is found by the dead-stop indication. It is signaled by a sudden jump in the current strength (Pt-Pt electrode, 500 mV, and $10^{-7}$ amp sensitivity of the galvanometer). The method is not impaired by triethanolamine, glycol, slight amounts of chloride, nor by phosphate. (auth)

**1266** APPLICATION OF AN ABSORPTION CELL FOR DETERMINING OF SOME METALS BY ATOMIC ABSORPTION. Stupar, J. (Jozef Stefan Nuclear Inst., Ljubljana, Yugoslavia). Mikrochim. Acta, No. 4-5, 722-36(1966).

Atomic absorption measurements of iron, cobalt, copper, silver, and lead were carried out using a specially constructed glass absorption cell. The best concentration range for measurements was found to be between 0.1 and 1 $\mu$g/ml and in some cases even lower. Reproducibility was good. The influence of 15 common elements in various concentrations was investigated for all five elements measured, and the results are discussed. Trace elements were separated from large quantities of other elements by extraction, and the method was used for their determination in nuclear-grade uranium, water samples, plants, and soil extracts. The results were accurate and reproducible, and the method was convenient because of its high sensitivity, simplicity, and rapidity. (auth)

**1267** SPECTRAL ANALYSIS OF URANIUM COMPOUNDS. Kelen, E.; Vorsatz, B. (Zentralforschungsinstitut fuer Physik, Budapest). Mikrochim. Acta, No. 4-5, 737-41(1966). (In German).

A procedure is given for determining the impurities in uranium based on a partial resolution. Some difficulties in spectral analysis are avoided in ac arc excitation. The partial resolution is accomplished with the aid of a mirror set in vibration electromagnetically. It can be combined with various spectrographs. (auth)

**1268** INVESTIGATION OF FACTORS AFFECTING THE ACCURACY AND SENSITIVITY OF THE FLUOROMETRIC DETERMINATION OF URANIUM. Samsoni, Zoltan (Magyar Tudomanyos Akademia Atommag Kutato Intezete, Debrecen, Hungary). Magyar Kem. Foly., 72: 398-404(Sept. 1966) (In Hungarian).

Control measurements were made on factors affecting the accuracy and sensitivity of fluorometric determination of uranium. It has been found that ether extraction is by far the best method for the preliminary separation and purification of the uranium content of the sample. The composition of the leaching solution was 250 g of $Al(NO_3)_3 \cdot 9\ H_2O$ + 125 ml of 1.5 M $HNO_3$. The influence of the composition and quantity of the molten bead, heating period, temperature, and conditions of cooling on the intensity of the fluorescence produced, and its stability on standing were studied. The following optimum parameters were established: basic composition of bead: 30% of NaF + 70% of $NaKCO_3$; 50 mg; 10 minutes heating at 650° in an electric oven. After the heating period, the oven is switched off, and the material is allowed to cool slowly; after 2.5 hours the sample is removed from the oven at about 280°, and analyzed within 1 or 2 hours. The preparation retains practically the same fluorescence for 24 hours, to be followed by a slow decrease. (auth)

**1269** ELIMINATION OF COLOR QUENCH IN LIQUID SCINTILLATION COUNTING OF $^{14}$C-CAROTENOIDS. Walter, William M. Jr.; Purcell, Albert E. (North Carolina State Univ., Raleigh. Dept. of Agriculture, Raleigh, N. C.). Anal. Biochem., 16: 466-73(Sept. 1966).

Four different systems were investigated in an attempt to eliminate the color quench in liquid scintillation counting of $^{14}$C-labeled-carotenoids. The methods tested on lycopene, but equally applicable to other carotenoids, were: a hydrogenation system, treatment with an acidic solution of N-bromosuccinimide, and agitation with chlorine water. The preferred method was decolorization with benzoyl peroxide and light. Using internal $^{14}$C-standards and 1 mg of lycopene, the counting efficiency was about 0.5 to 1%; however, after 1 to 3 hr of decolorization with the benzoyl peroxide, counting efficiencies of over 80% were obtained. Similar results were obtained using an external standard to determine efficiency. (B.L.M.)

**1270** MEASUREMENT OF RADIOCARBON CONTENT IN RICE. Hsu, Yin-chi; Lu, Shih-chong; Tai, Yuin-kwei (National Taiwan Univ., Taipei, China). Chin. J. Phys. (Taiwan), 4: 35-7 (Apr. 1966).

The radiocarbon content in rice sample that grew in Taiwan area has been measured. The results show that the radiocarbon content in spring rice has a high value, but its relative concentration (the ratio of radiocarbon content in rice to that in the atmosphere) is less than that of the fall rice. (auth)

**1271** A SIMPLIFIED METHOD OF SAMPLE PREPARATION FOR DETERMINATION OF TRITIUM, $^{14}$C, OR $^{35}$S IN BLOOD OR TISSUE BY LIQUID SCINTILLATION COUNTING. Mahin, Dorsey T.; Lofberg, Robert T. (Walter Reed Army Inst. of Research, Washington, D. C.). Anal. Biochem., 16: 500-9(Sept. 1966).

A safe method is described by which animal fluids, including whole blood, or animal tissues (including whole bone), may be solubilized into a colorless, stable liquid for a scintillation sample and measured for the content of tritium, $^{35}$S, or $^{14}$C, with good absolute efficiency and without phosphorescence. The protein is digested and heme is completely decolorized by heating the sample to 60 to 80°C after the addition of 60 to 70% $HClO_4$ and 30% $H_2O_2$. The resulting clear solution is dissolved into toluene–phosphor solution by means of a suitable secondary solvent. The simplicity of the method permits preparation of large numbers of samples with ease and with a minimum of equipment. (B.L.M.)

**1272** SIMULTANEOUS QUANTITATIVE DETERMINATION OF TWO GAMMA-RADIATING ISOTOPES WITH A SINGLE-CHANNEL PULSE HEIGHT ANALYZER. Fodor-Csanyi, P.; Gallyas, M. (Hungarian Academy of Sciences, Budapest). Acta Chim. Acad. Sci. Hung., 49: 225-42(1966)

The simultaneous quantitative determinations of $^{22}$Na and $^{131}$I, and of $^{137}$Cs and $^{131}$I were carried out with a single-channel pulse height analyzer; the spectra were evaluated by four different methods. McIsaac's method was found inadequate even for the evaluation of pure photopeaks (photopeaks not superimposed on Compton continuum). The greatest accuracy was achieved by Covell's method; the 1 to 2% standard deviation of the measurements was adequate. The results indicated that Covell's method may be applied not only to the cesium-zinc pair, but also to other isotope pairs, with the difference that the area under the photopeak, when calculated with Covell's equation, does not reach a saturation value, but instead a maximum is obtained, which is accepted as the measure of this area. To reduce the time necessary for taking the evaluation of the spectra, Covell's method was modified. The position of the slit was adjusted to a discriminator voltage corresponding to the left side minimum of the area below the photopeak, and this area was measured with a (2 n + 1) V slit width [where n is the number of channels necessary for reaching the saturation (maximum) N value]. It is sufficient to carry out three measurements, that of the area below the photopeak and of the number of counts of the last two channels included in the measurements; from these data the area below the photopeak free of the Compton continuum may be calculated by Covell's method. There was no agreement between the values obtained for the area below the photopeak when calculated from the sum of the number of counts and when measured directly with a (2 n + 1) V slit width. To eliminate this discrepancy, a conversion factor was introduced. This factor represents the ratio of the values of the area below the photopeak and is, under certain conditions, characteristic of the isotope studied. Provided the conversion factor is known, Covell's equation may be applied to calculation of the area below the photopeak. Though the statistical error involved in the modified Covell method was about twice that of the original method, there was no significant change in the standard deviation of the measurement. The modified method reduces the time required for the evaluation of the spectra to 20 to 25 minutes. (auth)

**1273** SOME RECENT HARWELL WORK ON ACTIVATION ANALYSIS. Pierce, T. B.; Smales, A. A. (Atomic Energy Research Establishment, Harwell, Eng.). Z. Anal. Chem., 221: 80-5(1966).

A review is given of recent work at Harwell on activation analysis. Slow and fast neutrons, charged particles, and $\gamma$ rays all play their part as activating agents and examples are given. The measurement of "prompt" radiation using charged-particle irradiation is also mentioned. (auth)

**1274** DETERMINATION OF DETECTION LIMITS IN ACTIVATION ANALYSIS WITH GAMMA SPECTROMETRY. Schulze, Werner (Freie Univ., Berlin). Z. Anal. Chem., 221: 85-100 (1966). (In German).

Fundamental relations were derived for the amount of an element detectable by nondestructive activation analysis in presence

of some arbitrarily chosen matrix material. Various cases in simple $\gamma$ spectrometry are discussed, as well as coincidence methods. As an aid for the calculation of matrix counting-rates, a table was prepared, which shows the relative distribution of pulses in $\gamma$ spectra up to 2.7 MeV for channels which extend over the half-width of the corresponding peaks. For the case of different half lives in peak and background a diagram is given showing the most favourable counting time. The relation, derived for detectability of $\gamma$-$\gamma$ coincidences, shows that the random rate is not restricted only to fractions of the true coincidence rate, but is allowed to have values some hundred times greater than the true coincidence rate, especially in presence of high channel counting-rates. (auth)

**1275** USE OF FAST REACTOR NEUTRONS FOR RAPID AND NONDESTRUCTIVE TRACE ANALYSIS, ESPECIALLY OF OXYGEN. Aumann, D. C.; Born, H. J.; Henkelmann, R. (Technische Hochschule, Munich). Z. Anal. Chem., 221: 101-8(1966). (In German).

The intense fast-neutron fluxes, which are available in nuclear reactors, can be used for rapid and nondestructive activation analysis of many elements. Some elements have superior detection limits for activation with fast reactor neutrons compared to reactor thermal-neutron activation. Short-lived radionuclides can be measured using a fast pneumatic tube system. Oxygen can be determined by the nuclear reaction $^{16}O(n,p)^{16}N$ initiated by fast reactor neutrons counting the high-energy gamma rays of the 7.4-sec $^{16}N$. The method is suitable for determining as little as 10 ppM of oxygen in many types of analytical samples. The fast transfer system, which is used in the Munich research reactor for rapid and nondestructive activation analysis, is described. The use of the transfer-system for oxygen activation analysis and problems associated with oxygen analysis are discussed. (auth)

**1276** RAPID ISOTOPIC SEPARATION METHODS FOR SELECTIVE DETECTION OF SHORT-LIVED RADIOISOTOPES. Loepfe, E.; Monnier, D.; Haerdi, W. Z. Anal. Chem., 221: 109-19(1966). (In German).

A method of radiochemical separation is proposed in which metallic mercury or its diluted amalgams are employed as extraction agents. The method is denoted by "isotopic exchange" when the particles exchanged are of the same chemical nature, or by "redox exchange," when the separation is controlled by redox phenomena. By means of electrokinetic and metallurgical considerations the field of application of this method was demarcated. Kinetics and influence of medium in the isotopic exchange of mercury ions, and in the redox exchange of silver, gold, and platinum ions with mercury of high purity were examined. Even in labeled organic compounds covalently bound mercury is exchanged in less than 3 min when an ionic exchange scavenger is added. The influence of complex formation constants on the exchange equilibrium was demonstrated for the case of silver ions. It will be quantitative only in presence of an ammonia buffer. For the same reason the exchange will be highly selective for mercury ions in the presence of cyanide ions. The determination of 0.09 ppM of gold in pyrite samples (irradiation: 30 min at $10^{13}$ n $\cdot$ cm$^{-2}$ $\cdot$ sec$^{-1}$) was mentioned as a first application of the new separation method. (auth)

**1277** USE OF NEUTRON ACTIVATION ANALYSIS FOR DETERMINATION OF IMPURITIES IN PURE COPPER. Lihl, F.; (Technische Hochschule, Vienna); Patek, P.; Sorantin, H. Z. Anal. Chem., 221: 176-86(1966). (In German).

The application of neutron activation analysis to the determination of impurities in pure copper is reported. After a theoretical introduction about the activation of the expected elements and possible errors, the preparation of samples, irradiation techniques, and $\gamma$-spectrometric measurements are described. The elements antimony, selenium, iron, silver, cobalt, zinc, nickel, and gold could be determined nondestructively. The quantitative determination was only possible after working out a chemical separation scheme, because of the activity of the matrix element and because of the overlapping of $\gamma$-energies. For comparison other analytical methods, x-ray fluorescence analysis and emission spectroscopy, were used, including the determination of lead and tin. The results of all analytical methods mentioned were in good agreement. The neutron activation method proved to be of high sensitivity and accuracy, but low rapidity in comparison to x-ray and emission spectroscopy. (auth)

**1278** TRACE ANALYSIS OF URANIUM IN ROCKS WITH THE HELP OF NEUTRON ACTIVATION. Turkowsky, C.; Staerk, H. (Technische Hochschule, Munich). Z. Anal. Chem., 221: 205(1966). (In German).

Amounts of uranium as small as 0.01 to 0.1% can be determined in rocks by neutron activation methods. After irradiation of the sample with resonance neutrons, uranium is extracted, and the $^{239}U$ counted. About 0.05 $\mu$g uranium/100 mg stone can be determined. (M.C.G.)

**1279** DETERMINATION OF OXYGEN IN URANIUM CARBIDE ACCORDING TO A NEW BATHLESS CARRIER METHOD. Nickel, H.; Rottmann, J.; Stoecker, H. J.; Naoumidis, A.; Koester-Pflugmacher, A. (Kernforschungsanlage, Juelich, Ger. Technische Hochschule, Aachen). Z. Anal. Chem., 221: 206-22 (1966). (In German).

Determination of oxygen in uranium carbide by a method of hot extraction in a stream of nitrogen replacing the molten bath of the vacuum fusion method is reported. The nitrogen is not only used as a carrier gas but also as a chemical reactant, which by the formation of stable nitrides and carbonitrides removes the oxygen impurities present as $UO_2$ and U(C,O) in the uranium carbide. The utility of the method was demonstrated by the results of several series of determinations which were obtained under comparable conditions by vacuum fusion and by the use of argon as carrier gas. The results of thermodynamic calculations on the reaction mechanism of the removal of oxygen from UC-samples by hot extraction without fusion using a stream of nitrogen carrier gas as well as vacuum could be confirmed by chemical, x-ray diffraction, and metallographical analysis of outgassed samples. By avoiding the use of a molten-metal bath the nitrogen carrier gas method presents the following advantages over the fusion methods: the troublesome influence of graphite precipitations in the liquid metal bath on the process of dissolution and outgassing is avoided; losses of the gas by gettering on vaporized metal are avoided; use of the graphite crucible several times and the saving of capsules and bath materials reduce the cost of series determinations. The applicability of this method is not limited to the determination of oxygen in uranium compounds. All elements the oxides of which react with carbon in a stream of nitrogen and form stable nitrides or carbonitrides and CO may be analysed by this method. (auth)

**1280** ACTIVATION ANALYSIS INVESTIGATION OF PAINTINGS. DETERMINATION OF TRACE CONTENTS OF WHITE LEAD OF PAINTINGS OF THE ALTE PINAKOTHEK AT MUNICH. Lux, Franz; Braunstein, Lothar (Technische Hochschule, Munich). Z. Anal. Chem., 221: 235-54(1966). (In German).

Trace concentrations of Mn, Cu, Ba, Cr, Ag, and Sb in white-lead samples of paintings of the "Alte Pinakothek" were determined by activation analysis. In model experiments an analytical method comprising radiochemical separation and $\gamma$ spectroscopy was developed. The limits of identification were about $5 \times 10^{-10}$g for Ba, $2 \times 10^{-10}$g for Cr, $10^{-10}$g for Ag and Cu, and $10^{-11}$g for Mn and Sb. Sometimes there was only 10 $\mu$g of white lead for one analysis. Predominately white-lead samples from paintings of Venetian and Dutch masters of the 16th and 17th centuries were analyzed. Modern and old white lead show great differences mainly in Cu and Ba concentrations; this may be used for the recognition of forgeries. (auth)

**1281** ANALYSIS OF CERIUM IN CERIUM-STABILIZED STEEL. Eckhard, S.; Sauer, K. H.; Marotz, R. (Max-Planck-Institut fuer Eisenforschung, Dusseldorf). Z. Anal. Chem., 221: 285-99(1966). (In German).

Cerium not only is used to form nodular graphite in spheroidal cast iron, but influences some mechanical properties of steel. The killing of molten steel by misch metal causes oxide inclusions in the steel, which include cerium and other rare earths. In the oxide inclusions normally Al, Ca, Cr, Fe, Mg, Mn, Si, and Ti can be determined by the spectrographic procedure formerly developed by Eckhard, Koch and Mahr; the same method can be transferred to other elements by selecting suitable detection lines of the elements concerned. Cerium cannot be detected in this manner. The reasons of the failure are discussed and a modified method for the determination of cerium in oxide inclusions is described. The direct determination of cerium in steel is discussed. All results obtained in the optical wave-length range are rather unsatisfactory. Methods of x-ray fluorescence analysis were tried and they seem to be rather adequate to solve all analytical problems resulting from the use of misch metal in the metallurgy of iron and steel. (auth)

**1282** DETERMINATION OF SMALL HELIUM AMOUNTS IN SOLID BODIES. Alimova, I. A.; Boltenkov, B. S.; Gartmanov, V. N.; Mamyrin, B. A.; Shustrov, B. N. (Ioffe Physico-Technical Inst., Leningrad). Geokhimiya, No. 9, 1044-9(Sept. 1966). (In Russian).

A method for determining helium in solid samples weighing up to 60 g was developed. The all-metal system for gas extraction allowed the complete isolation of small amounts of helium from samples by fusing and evaporating them in a vacuum. The analysis was made using the dynamic mass spectrometer in the sta-

tionary regime. The method allowed the determination of $10^8$ atoms of $^3$He and $10^{10}$ atoms of $^4$He, which corresponds to samples weighing tenths and hundredths of a milligram in the analysis of meteorites. (D.H.M.)

**1283** GOLD IN GRANITES OF THE ALTAI AND TRANSBAIKAL (ACCORDING TO DATA OF THE RADIOACTIVATION ANALYSIS). Anoshin, G. N.; Potap'ev, V. V. (Inst. of Geology and Geophysics, Novosibirsk, USSR). Geokhimiya, No. 9, 1070-4(Sept. 1966). (In Russian).

Results of a gold determination in granites of multiphase massifs by activation analysis are given. The average gold content in granites of both massifs was 0.0012 g/t. The average content in rock-forming minerals was: in quartz 0.0008 g/t, in feldspars 0.0003 g/t. A change of gold contents according to phases was not observed. Mobility of gold in the process of a high-temperature hydrothermal alteration of granites is considered. (auth)

**1284** URANIUM CONTENT IN ATMOSPHERIC AEROSOLS. Smirnov, L. E.; Kononova, L. N. Geokhimiya, No. 9, 1126-8 (Sept. 1966). (In Russian).

The luminescence method was used for determining uranium in atmospheric aerosols taken at 2 to 10 km elevation during 1959. The amount of U in the troposphere was higher at the beginning of 1959 due to the nuclear tests carried out in 1958. It was assumed that the concentration of uranium at the end of 1959 was approaching the natural uranium concentration. Comparisons between the content of U in the atmosphere during August and September of 1963 and the content at the end of 1959 confirmed the assumption. (R.V.J.)

**1285** LOW $^{90}$Sr-ACTIVITY DETERMINATION IN WATER. Krepelka, Jiri; Kasak, Frantisek (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Jad. Energ., 12: 368-71(Oct. 1966). (In Czech).

A method of $^{90}$Sr determination in potable, surface, and waste waters is described. The large volumes of a sample are concentrated using an ion exchanger and calcium present is bound on chelaton III. Strontium is separated by the coprecipitation with $BaSO_4$ in the chelaton medium, $^{90}$Sr is determined by measurement of $^{90}$Y. This method enables the $^{90}$Sr determination in concentrations of the order of $10^{-13}$ Ci/l. (auth)

**1286** ACCURACY EVALUATION OF THE FORMERLY PROPOSED CORRECTION FACTOR FOR ITS PRACTICAL APPLICATION IN ACTIVATION ANALYSIS. Rakovic, Miloslav; Prochazkova, Zdenka (Charles Univ., Prague). Jad. Energ., 12: 384-6 (Oct. 1966). (In Czech).

Practical application of the formerly proposed correction relation in activation analysis was studied. Both the error originated by the approximation in deriving this relation, and the influence of exactness in determining values introduced to it on the exactness of the result of analysis are evaluated. (auth)

**1287** STRUCTURE OF THE AEROBACTER AEROGENES A3(S1) POLYSACCHARIDE. II. SEQUENCE ANALYSIS AND HYDROLYSIS STUDIES. Conrad, H. E.; Bamburg, J. R.; Epley, J. D.; Kindt, T. J. (Univ. of Illinois, Urbana). Biochemistry, 5: 2808-17(Sept. 1966).

Quantitative radiochemical methods for determination of reducing equivalents and for radiochromatographic analysis of oligosaccharide mixtures were developed for use in structural studies of the slime polysaccharide from Aerobacter aerogenes, A3(S1). Partial acid hydrolysis of the polysaccharide yields a single neutral disaccharide, identified as cellobiose, and three glucuronic acid containing oligosaccharides, a di-, a tri-, and a tetrasaccharide, each of which has L-fucose at the reducing terminal. Sequence analysis data, taken with the previous methylation data, were used to determine the structure of the polysaccharide. (C.H.)

**1288** URANYL REACTIONS WITH XANTHATES. Larionov, S. V.; Shulman, V. M.; Efremova, T. D. (Inst. of Inorganic Chemistry, Academy of Sciences, Siberian SSR, Novosibirsk State Univ., USSR). Izv. Sibirsk. Otd. Akad. Nauk SSSR, No. 7, Ser. Khim, Nauk, No. 2, 85-8(1966). (In Russian).

An optical method was used for the analysis of the uranyl ethylxanthate complex (EX) formation in cyclohexanone. Stability constants were computed for complex compounds in the system as follows: $\log K_1 = 4.4 \pm 0.3$, $\log K_2 = 3.8 \pm 0.1$, and $\log K_3 = 3.45 \pm 0.1$. The results indicate the feasibility of using complex formation of $UO_2^{2+}$ and EX for uranium extraction from neutral solutions by means of cyclohexanone. (R.V.J.)

**1289** NEW ASPECTS AND POSSIBILITIES OF STABLE ISOTOPE ANALYSIS. Mercea, V. Isotopenpraxis, 2: 313-22(Aug. 1966). (In German).

Trends in the development of the gas-chromatographic analysis of stable isotopes, of optical analysis of stable isotopes, and of mass-spectrometric analysis of stable isotopes are discussed. (auth)

**1290** AN AUTOMATIC ACTIVATION ANALYSIS SYSTEM (AAAS) WITH THE USE OF FAST NEUTRON GENERATOR. Barwinski, A.; Gorski, L.; Janczyszyn, J.; Korbel, K.; Kwiecinski, St.; Loska, L.; Ostachowicz, J. (Inst. of Nuclear Techniques, Krakow). Isotopenpraxis, 2: 322-8(Aug. 1966).

The system described is designed for automatic activation analysis with 14-MeV neutrons. The automation includes all operations and time control of the activation cycle. There is a possibility of independent programming of the irradiation time, the decay time, and seven consecutive measuring periods in the range from 3 sec to 80 min by means of a special time control unit. The dispatch of containers with samples is done with a very simple pneumatic device. The design and effectiveness of shieldings against fast neutrons are also described. (auth)

**1291** THE DETERMINATION OF RADIOACTIVE IODINE IN NATURAL WATER, MILK, AND THYROID GLAND. Tanaka, Giichiro (National Inst. of Radiological Sciences, Chiba, Japan). Bunseki Kagaku, 15: 1068-73(Oct. 1966). (In Japanese).

A method for the determination of radioactive iodine was developed for use in environmental contamination survey. This method is suitable for low-activity samples, and several pCi of radioiodine per sample can be determined. After the addition of iodine carrier ($I^-$ 15 mg), with the exception of thyroid, samples are treated as follows: water: five liters of alkaline water are concentrated to 500 ml, and iodine is reduced to iodide with sodium thiosulfate and then oxidized to iodate with sodium hypochlorite; milk: to 250 ml of milk is added 6.6 g of sodium hydroxide, and they are wet-ashed. The ashing is completed by an alkaline fusion with potassium nitrate; and thyroid: 30 g of thyroid gland (without a carrier added) are ashed with alkali, and then destroyed by alkali fusion. Stable iodine in the same thyroid gland (2 g) is determined by isotope dilution and a colorimetric method using 516 mμ absorption of iodine in carbon tetrachloride. Iodate is reduced to iodide with hydroxylamine hydrochloride, and the iodine is extracted into carbon tetrachloride after adding sodium nitrite and nitric acid to the solution. Iodine is back-extracted into the aqueous phase after its reduction with sulfurous acid, and is precipitated as silver iodide. The solution is filtered through a filter paper, and the precipitate washed with water and ethanol. The precipitate together with filter paper is placed on a stainless steel counting tray, dried at 110°C for 30 min, and is weighed to determine the recovery of the iodine. Radioactivity of the precipitate is measured by a low-background beta counter, and the results are corrected for geometry, self-absorption, etc., by using standard IAEA $^{131}$I solution. (auth)

**1292** SPECTROPHOTOMETRIC DETERMINATION OF RARE EARTH ELEMENTS WITH PYROCATECHOL VIOLET. Takano, Tsuneo (Ibaraki Univ., Japan). Bunseki Kagaku, 15: 1087-92(Oct. 1966). (In Japanese).

A method is described for the spectrophotometric determination of lanthanum, cerium, praseodymium, neodymium, gadolinium, dysprosium, holmium, erbium, thulium, and ytterbium with Pyrocatechol Violet. Potassium cyanide was used to eliminate the interference from cobalt, nickel, copper, zinc, cadmium, and mercury present in the sample solution. The absorbance is measured in a 10-mm cell at 665 mμ against the reagent blank as the reference. Beer's Law is obeyed in the concentration range of 0 to 120 μg rare earth element per 25 ml. Results of the continuous variation method indicate that the mole ratio of rare earth element to Pyrocatechol Violet is 1:1. The molar absorptivity at 665 mμ is given for the 10 rare earth elements. (auth)

**1293** X-RAY FLUORESCENCE SPECTROMETRIC DETERMINATION OF YTTRIUM BY SOLUTION METHOD. Asada, Eiichi; Matsuda, Shoji (Government Chemical Industrial Research Inst., Tokyo). Bunseki Kagaku, 15: 1104-9(Oct. 1966). (In Japanese).

Fundamental studies were made on the fluorescent x-ray analysis of a solution of yttrium in nitric acid, and a linear relation was obtained between the reciprocal concentration (1/W) and the reciprocal intensity of fluorescent x-rays (1/I), both theoretically and experimentally. The value of 1/I when $1/W \rightarrow 0$ proved to be constant and independent of the matrix elements. A method for determination of yttrium based on these relations was proposed and applied to the determination of yttrium in rare earth mixtures. The results indicated that the relative error in the determination is about 3% even in a highly concentrated solution of yttrium. The proposed method required neither examination of the linearity of calibration line nor dilution process necessary in the conventional standard addition method. (auth)

**1294** DETERMINATION OF $^{14}$C, $^3$H, AND $^{35}$S IN SEVERAL LABELED COMPOUNDS AS WELL AS IN ISOTOPIC MIXTURES

BY LIQUID SCINTILLATION. Kainz, Gerald; Wachberger, Eugen (Univ., Vienna). Z. Anal. Chem., 222: 10-14(1966). (In German).

A method is described for the determination of $^{14}C$, $^{3}H$, and $^{35}S$ by converting these isotopes into the corresponding oxidation products (by combustion at nozzles) followed by separation of the oxidation products. The oxides of $^{35}S$ are absorbed on silver and counted after elution of silver sulfate. $^{3}H$ is trapped as water in acidified methanol, and $^{14}C$ is retained as $CO_2$ in ethanolamine-methanol. In all cases each isotope may be determined in the absorbent by direct liquid-scintillation counting. (auth)

**1295** THE CHOICE OF CONDITIONS FOR THE ION EXCHANGE CONCENTRATION AND DETERMINATION OF MICRO-IMPURITIES IN THE ANALYSIS OF SUBSTANCES OF HIGH PURITY. Nikitina, N. G.; Galkina, N. K.; Senyavin, M. M. (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim., 21: 1165-71(1966). (In Russian).

The selection of optimum conditions for the ion exchange concentration of impurities from pure solutions is discussed. A method was developed for determining traces of chlorine and sodium ions in water of high purity. Conditions were studied for the total ion exchange concentration of impurities on the KU-2 and KB-4 cation exchangers followed by their spectrographic determination. Optimum conditions were found for the ion exchange concentration of impurities from salt solutions with separation of the components. A method was developed for determining traces of radioactive elements in river and water-pipe water. (auth)

**1296** DETERMINATION OF SMALL AMOUNTS OF TERBIUM, DYSPROSIUM, AND GADOLINIUM IN YTTRIUM OXIDE BY A LUMINESCENT METHOD. Karyakin, A. V.; Anikina, L. I.; Filatkina, L. A. (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim., 21: 1196-1200(1966). (In Russian).

A luminescent method was developed for determining terbium and dysprosium in yttrium using crystallophosphors on the base of $Y_2O_3 + CaF_2$ (1:1) and for determining gadolinium in yttrium using crystallophosphors on the base of $Y_2O_3$. The sensitivity of the method is $1 \cdot 10^{-4}$ and $5 \cdot 10^{-4}$%, correspondingly. The reproducibility is about 20–30%. (auth)

**1297** DETERMINATION OF NITROGEN IN TITANIUM BY AN ISOTOPE-DILUTION METHOD. Orlova, K. B.; Vitol, E. N. Zh. Anal. Khim., 21: 1263-6(1966). (In Russian).

An isotope dilution method was used for the determination of nitrogen in titanium. Results obtained are in good agreement with data of the chemical method. Sensitivity of the isotope dilution method is one order higher than that of the chemical method. It is $5.10^{-4}$% (weight) for a 1 g sample. (auth)

**1298** A SEMIMICROMETHOD FOR THE DETERMINATION OF ISOTOPIC COMPOSITION OF OXYGEN IN WATER BY THE ISOTOPIC EXCHANGE OF $H_2O^*$ WITH $KMnO_4$. Volnov, I. I.; Chamova, V. N.; Salimova, K. M. (Kurnakov Inst. of General and Inorganic Chemistry, Moscow). Zh. Anal. Khim., 21: 1262-3(1966). (In Russian).

Determination of the isotopic composition of oxygen in water by the reaction of isotopic exchange with $KMnO_4$ at 100° and 100-time excess of water was carried out with samples of 0.5 ml of $H_2{}^{18}O$ and 0.01 g of $KMnO_4$. The time necessary for the exchange is 6 hr. (auth)

**1299** SUBSTOICHIOMETRIC DETERMINATION OF HEAVY RARE EARTHS BY ISOTOPIC DILUTION ANALYSIS. Prasilova, Jarmila (Faculty of Technical and Nuclear Physics, Prague). Talanta, 13: 1567-71(Nov. 1966).

A substoichiometric method for the determination of heavy rare earths (holmium, thulium) was developed. After the addition of a substoichiometric amount of EDTA to the test sample of rare earth labeled with its radioactive isotopes, the negatively charged complex formed was separated by passage through a column of Dowex 50 × 8. Interfering metals can be removed by preliminary cupferron and diethylammonium diethyldithiocarbamate extraction. Concentrations of rare earth down to $4 \times 10^{-7}$ g/5 ml were determined. (auth)

**1300** METHOD OF ACTIVATABLE TRACERS AND ITS RECENT APPLICATIONS TO GLASS MAKING AND PETROLEUM. Bondy, Charles; Vidal, Jean-Pierre; Robin, Gerard. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl., No. 61, 11-15(Sept.-Oct. 1966). (In French).

In cases where the use of radioactive tracers is not suitable, a non-active tracer can be introduced into the system to be studied. The presence of the tracer is then determined by neutron activation analysis. Some examples are given of neutron activation tracer techniques in glass making and petroleum industries. The general conditions under which this technique is usable are outlined. The examples given include determination of the origin of a motor oil, determination of optimum priming conditions in distillation columns, measurement of displacement time of a distillation unit, and measurement of the residence time of glass in a furnace. The steps in the activation tracer technique are outlined. (J.S.R.)

**1301** COMPLEXES OF ANTHRANILDIACETIC ACID WITH TRIVALENT METALS. II. SCANDIUM, YTTRIUM, AND LANTHANUM. Dragulescu, C.; Policec, Septimia; Simonescu, T. Talanta, 13: 1543-8(Nov. 1966). (In French).

A spectrophotometric study of the complexes formed between anthranil-N,N-diacetic acid (ANDA) and scandium, yttrium, and lanthanum, led to the development of methods for the determination of these elements. The instability constants for the complexes, in which the Me : ANDA ratio is 1 : 1, were found to be $1.5 \times 10^{-6}$, $3.4 \times 10^{-6}$, and $2.9 \times 10^{-6}$ for Sc-ANDA, Y-ANDA, and La-ANDA respectively. (auth)

**1302** ISOTOPIC EXCHANGE CHROMATOGRAPHIC SEPARATION APPLIED TO AN EQUILIBRIUM $^{90}Sr$ AND $^{90}Y$ MIXTURE. Hamaguchi, Hiroshi (Tokyo Univ.); Onuma, Naoki; Watanabe, Toshi; Kuroda, Rokuro. Nature, 211: 1295-6(Sept. 17, 1966).

A column of strontium sulfate was used for the rapid chromatographic separation of carrier-free $^{90}Y$ from $^{90}Sr$. The bed, 1.3 cm long, was treated with 0.5 N sulfuric acid. An equilibrium mixture of $^{90}Sr$ and $^{90}Y$, converted to sulfate form and adjusted to 0.5 N in sulfuric acid, was added to the column. Fractions of eluate covering the entire elution profile were used for decay rate measurement and gamma spectrometry. A similar radiochemical method using a column of cerium(IV) iodate crystals was applied to the separation of $^{144}Ce$ and $^{144}Pr$. (J.G.B.)

**1303** CALIBRATION OF URANIUM METAL FOILS AS STANDARDS BY AN ALPHA-GAMMA COINCIDENCE METHOD. Nelson, L. C. Jr.; Zyskowski, C. (Atomic Energy Commission, New Brunswick, N. J.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/23, 16p. (CONF-661012-20). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

Methods for the nondestructive determination of the total uranium-235 or the uranium-235 enrichment level in fabricated fuel elements, or fuel element assemblies, by gamma-ray spectrometry depend upon a comparison of the unknown unit with an almost identical, known unit or upon the destructive analysis of at least one of several units being analyzed. An alternative to this is to make corrections for the self absorption of the gamma rays in each unit analyzed. The most common method uses transmission-type absorption data to calculate the mass absorption coefficient. It has been shown that when these corrections are appreciable, errors are introduced giving results that are not consistent. In addition, when different cladding or alloying metals are used, unknown absorption factors are sometimes introduced making a correct analysis difficult. If, however, the disintegration rates and decay of the several isotopes of uranium were well known, and if the efficiency of the various detectors were known accurately, then the absorption coefficients for almost any configuration could be calculated. Studies of the decay schemes were made using electrodeposited films of National Bureau of Standards isotopic uranium standards and both a surface barrier-type semiconductor alpha detector and a lithium-drifted germanium gamma-ray detector. Estimates of the energies and relative yields of both the alpha particles and the gamma rays were made. These results were then used to set up the surface barrier detector and a sodium iodide gamma-ray detector to study and measure the alpha-gamma coincidences so that quantitative measures of the decay rates from each of the electrodeposited films could be made. The weight of uranium in each film was calculated from the decay rate, the known isotopic distributions, and the decay schemes. The self absorption of the films was assumed to be negligible. Inherently, then, the detector efficiencies were obtained from the coincidence data. The uranium metal foils of finite thickness and mockups with various cladding materials were assembled and measured to determine gamma-ray attenuation, scatter, and geometrical efficiencies of various systems. Data and figures are presented showing the alpha particle and gamma-ray spectra, their energies, and yields wherever new or improved data were determined. (auth)

**1304** OXYGEN DETERMINATION USING TRITON ACTIVATION. de Goey, J. J. M.; Houtman, J. P. W. (Reactor Instituut, Delft, Netherlands). 25p. (CONF-650405-27). ORAU.

From International Conference on Modern Trends in Activation Analysis, College Station, Tex.

The determination of oxygen by triton activation was applied to the analysis of foils covered with Li-containing films and to powders in a mechanical mixture containing a Li compound. Data are

tabulated for relative ranges of tritons and relative stopping powers of certain substances, which make it possible to compare $O_2$ contents, and thus also the $^{18}F$ activity, in different materials for various sandwich systems and for a homogeneous system. The relative range data also provide direct information about surface layer thickness. The method is discussed with particular reference to determination of $Al_2O_3$ layers on Al, of O in Li–Al–Mg alloy, of O in organic materials, and of surface O in polyolefins. The method suffers from interference from a number of elements, and chemical separation is often necessary. (B.L.M.)

**1305** SPARK SOURCE MASS SPECTROGRAPHIC ASSAY OF RARE EARTH METALS AND OXIDES. Conzemius, R. J.; Capellen, J.; Svec, H. J. 13p. (CONF-660537-4). ORAU. Gmelin, AED-CONF-66-175-7.

From 14th Annual Conference on Mass Spectrometry and Allied Topics, Dallas.

Several aspects of studies of spectrographic assay of rare earth metals and oxides using a spark source in routine service analyses are reported. The distribution of multiple charged ions, cluster intensities, interference problems, and reproducibility were studied. The oxide samples were pelletized with high purity graphite before sparking. All sample preparation and sparking conditions are discussed in detail. All evaluation of data recorded by photoplates was carried out by computers. (B.L.M.)

**1306** AUTOMATED, HIGH SPEED CHROMATOGRAPHIC SEPARATIONS IN THE ACTIVATION ANALYSIS OF SHORT-LIVED ISOTOPES. Cram, Stuart P.; Brownlee, James L. Jr. (Univ. of Illinois, Urbana). 23p. (CONF-660611-10). ORAU. Gmelin, AED-CONF-66-172-12

From Society of Applied Spectroscopy Meeting, Chicago.

Gas-liquid chromatography was applied to the separation of radiolysis degradation products containing short-lived isotopes. Rapid separations are achieved by use of a pneumatic transfer system to the injection port of the chromatograph, where automatic sampling occurs, placing the sample on the partition column as a plug volume. The speed of separation is limited only by the degree of resolution required as the solute bands must be retained in the flow-through counting geometry for a sufficient duration to obtain adequate statistics. The detector system consists of thermal conductivity, hydrogen flame ionization, and the NaI scintillation crystal for multichannel pulse height analysis and multichannel scaling. Circuits were developed, which allow complete automation of the analysis, timing to 0.1 sec of the irradiation and decay times, and the oscilloscopic display of all chromatographic data. This coupling of activation analysis and gas chromatography may be utilized as a "fingerprint" technique for organic compounds, as well as providing both a qualitative and quantitative detector system for chromatographic separations in general. (auth)

**1307** SENSITIVITY ENHANCEMENT FOR LOW LEVEL ACTIVITIES BY COMPLETE SYNTHESES OF LIQUID SCINTILLATION SOLVENTS. Tamers, M. A. (Instituto Venezolano de Investigaciones Cientificas, Caracas). 27p. (CONF-660612-3). ORAU. Gmelin, AED-CONF-66-194-1.

From Symposium on Organic Scintillators, Argonne, Ill.

A procedure for synthesizing a large part of the solvent for liquid scintillation measurements for low level radioactivity, from the material of the sample to be counted has been applied to three natural radioactivity dating methods for carbon-14, hydrogen-3, and chlorine-36. Benzene was found to be the most suitable compound for both carbon-14 and tritium measurements. The work on the synthesis of benzene for carbon-14 dating is now complete with yields approaching 100% and less than eight hours total chemical preparation time. Furthermore, the isotope effect for carbon proved to be small and reproducible to better than ½%. Although benzene contains only 8% hydrogen as compared to 92% carbon, the chemical technique for tritium measurements is considerably simpler than that used for radiocarbon dating. Due to the faster preparation, large quantities of benzene for tritium dating can be produced and the sensitivity increased in this way. An isotope effect of –34% was observed, but it seemed to be sufficiently reproducible not to pose a problem in the use of the liquid scintillation counter for tritium dating. A procedure is being developed for the synthesis of an inorganic liquid, silicon tetrachloride, from the chlorine of the sample to be dated. The chemical preparation is rapid and has an average yield of 75%, but the compound is not suitable for use without the presence of an organic solvent in which the scintillator must be dissolved. Despite this, with silicon tetrachloride much larger quantities than were previously possible can be counted, and the method offers promise of eventually making chlorine-36 dating practical. (auth)

**1308** ACTIVATION ANALYSIS OF SAMPLES OF NON-UNIFORM COMPOSITION USING A 14-MeV NEUTRON GENERATOR. Burns, Forrest C.; Priest, Grace L.; Priest, Homer F. (Army Materials Research Agency, Watertown, Mass.). 18p. (CONF-660611-9). ORAU. Gmelin, AEC-CONF-66-172-11.

From Society of Applied Spectroscopy Meeting, Chicago.

With the increasing use of 14-MeV neutron generators for neutron activation analysis, special problems have arisen because of the non-uniformity of the neutron flux. Various types of motions to insure uniform, reproducible irradiation of an unknown sample and a standard were studied. Two satisfactory solutions, one for cylindrical and one for disc-shaped samples, were found using a combined rotation traverse motion to sample the neutron flux. (auth)

# Inorganic, Organic, and Physical Chemistry

*Refer also to abstracts 1288, 1441, and 2061.*

**1309** (AERE-R-5249) FORTRAN PROGRAMMES FOR THE PROCESSING OF BOMB CALORIMETRY DATA. Hawtin, P.; Gardner, S. A.; Huber, R. A. (Atomic Energy Research Establishment, Harwell (England)). Aug. 1966. 22p. Dep. mn. BIS $0.70. HMSO 3s. 6d.

A series of FORTRAN (S2) computer programs for the evaluation of results obtained from an aneroid bomb calorimeter are described. These programs are: BEDTIME, which evaluates the delay time from the temperature-time data and hence allows the calculation of the corrected temperature rise from the observed value; ICEBERG, which calculates the standard energy equivalent of the bomb from a benzoic acid calibration; and ADHOC 2, which calculates the change in internal energy content of carbon on combustion and the corresponding heat of combustion. Programs ICEBERG and ADHOC 2 require a knowledge of the delay time, found via program BEDTIME or otherwise, and they are not therefore specific to data obtained from an aneroid bomb calorimeter. Additionally a sub-routine COWBUC, used to calculate the Washburn correction according to the method of Prosen, is described. (auth)

**1310** (AGN–8192(Vol.3)) THERMODYNAMIC AND TRANSPORT PROPERTIES OF CESIUM AND RUBIDIUM VISCOSITY OF LIQUID CESIUM AND RUBIDIUM. Achener, P. Y.; Boyer, M. R. (Aerojet-General Nucleonics, San Ramon, Calif.). Sept. 1966. Contract AT(04-3)-368. 45p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The viscosity of liquid cesium and rubidium was determined at temperatures from the melting points up to 1070°C. The experimental method involved the use of an oscillating cylinder viscometer. The equations proposed for the absolute viscosity of cesium and rubidium are, respectively: $\log_{10}\mu = 104.013/T - 0.59911 \log_{10}T + 1.8781$ and $\log_{10}\mu = 62.2374/T - 0.78639 \log_{10}T + 2.4459$ where $\mu$ is in millipoises and T in degrees Kelvin. (auth)

**1311** (BMwF-FBK-66-17) DIE DESORPTION VON RaE AUF NICKEL- UND GOLDOBERFLAECHEN IM VAKUUM. (The Desorption of RaE from Ni- and Au-Surfaces in High Vacuum). Dierker, J.; Trier, R. (Bundesministerium fuer Wissenschaftliche Forschung, Bad Godesberg (West Germany)). July 1966. 30p. (In German). Dep. mn. Gmelin: DM 6,00.

In order to determine the desorption probability for $^{210}Bi$ on Ni and Au surfaces an apparatus was constructed, which allows active and inactive materials to be evaporated, the activity to be measured as a function of time at several temperatures in high vacuum. The measured time dependence of the activity on the surfaces at several constant temperatures between 630 and 850°K can be separated in two parts with different desorption probability. The adsorption energy $E_{ad}$, according to the first part of the curve, which has an exponential form, was determined to be $E_{ad}$ ($^{210}Bi$ on Ni) = 2.05 ± 0.18 eV and $E_{ad}$ ($^{210}Bi$ on Au) = 2.46 ± 0.21 eV. (auth)

**1312** (BNWL-113-20) PLUTONIUM ABSTRACTS. Volume 6, Number 8. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 30, 1966. Contract AT(45-1)-1830. 39p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Seventy-nine abstracts on research and development in plutonium technology are presented under the following subject headings: biology and medicine, chemistry, health and safety, metallurgy, miscellaneous, physics, and reactor technology. (M.C.G.)

**1313** (CALT-221-24) MOESSBAUER EFFECT OF $^{125}Te$ IN SIMPLE CUBIC AND AMORPHOUS PHASES IN TELLURIUM-BASE ALLOYS. Report No. 46. Tsuei, C. C. (California Inst. of Tech., Pasadena. W. M. Keck Lab of Engineering Materials). Oct. 1966. Contract AT(04-3)-221. 13p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Recoilless resonant absorption of the 35.6-keV gamma ray ($^3/_2^+$ to $^1/_2^+$ transition) in $^{125}Te$ was observed in both simple cubic and amorphous tellurium-base alloys obtained by rapid cooling from the liquid state. As expected from its cubic symmetry, the simple cubic (one atom/unit cell) metastable $AuTe_2$ gives a single-peak Moessbauer spectrum with a half-width 0.88 cm/sec and an isomer shift of 0.08 cm/sec. The monoclinic $AuTe_2$, which is the equilibrium form of this compound, unexpectedly shows also a single-peak spectrum. However, the latter is about 24% broader than the former. On the basis of the atomic arrangement of the monoclinic $AuTe_2$, this line broadening is attributed to a weak quadrupole interaction. The Moessbauer spectrum of the metastable amorphous alloy $Te_{70}Cu_{25}Au_5$ exhibits a well-resolved quadrupole splitting of 0.74 ± 0.02 cm/sec which is about the same as that of crystalline tellurium. The fact that the amorphous alloy has a quadrupole splitting of the same magnitude as that of crystalline tellurium confirms the hypothesis proposed previously that the metastable amorphous tellurium-base alloys consist of randomly oriented spiral chains of tellurium, with the atoms of the minor constituent(s) randomly distributed between the chains. (auth)

**1314** (CEA-R-2882) CONTRIBUTION A L'ETUDE DES SOLUTIONS DE SELS D'URANYLE DANS LES PHOSPHATES BUTYLIQUES. (Contribution to the Study of Uranyl Salts in Butyl Phosphate Solutions). Coulon, Alain (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). 1966. 91p. Dep. mn.

Thesis. Submitted to Univ., Paris.

A spectroscopic study in the normal infrared region and involving the associations of trialkyl phosphates (tributyl, triethyl, trimethyl) with uranyl salts (nitrate, chloride, acetate) confirmed the existence of an interaction between the phosphoryl group and the uranium atom, as shown by a movement of absorption band for the valency P = 0 from ~1270 $cm^{-1}$ to ~1180 $cm^{-1}$. A study of the preparation, analysis, and spectroscopy of the solids obtained by the precipitation of uranyl salts by acid butyl phosphates was carried out. By infrared spectrophotometry it was shown that the tributyl and dibutyl phosphates are associated in non-polar diluents even before the uranium is introduced. The extraction of uranyl salts from acid aqueous solutions by a diluted mixture of tributyl and dibutyl phosphates proceeds by different mechanisms according to the nature of the ion (nitrate or chloride). (auth)

**1315** (CEA-R-2988) PREPARATION ET ETUDE DES NITRURES ET CARBONITRURES D'URANIUM ET DE PLUTONIUM. (Preparation and Study of the Nitrides and Mixed Carbide-Nitrides of Uranium and of Plutonium). Anselin, Francois (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). June 1966. 89p. Dep. mn.

Thesis.

A detailed description is given of a simple method for preparing uranium and plutonium nitrides by the direct action of nitrogen under pressure at moderate temperatures (about 400°C) on the partially hydrogenated bulk metal. It is shown that there is complete miscibility between the UN and PuN phases. The variations in the reticular parameters of the samples as a function of temperature and in the presence of oxide were used to detect and evaluate the solubility of oxygen in the different phases. A study was made of the sintering of these nitrides as a function of the preparation conditions with or without sintering additives. A favorable, but nonreproducible, effect was found for traces of oxide. The best results were obtained for pure UN at 1600°C (96% theoretical density) on condition that a well-defined powder was used. The criterion used is the integral width of the x-ray-diffraction lines. The compounds UN and PuN are completely miscible with the corresponding carbides. This makes it possible to prepare carbide-nitrides of the general formula (U,Pu) (C,N) by solid-phase diffusion at around 1400°C. The sintering of these carbide-nitrides is similar to that of the carbides if the nitrogen content is low; in particular, nickel is an efficient sintering agent. For high contents, the sintering is similar to that of pure nitrides. (auth)

**1316** (IS-T-97) A STUDY OF DIFFUSION IN BINARY LIQUID SYSTEMS USING NMR TECHNIQUES. Arnold, David Walker (Iowa State Univ. of Science and Technology, Ames). Aug. 1966. Contract W-7405-eng-42. 107p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

Thesis.

Self-diffusion coefficients of 2-component liquid systems were obtained from spin echo nuclear magnetic resonance observations. Self-diffusion data are reported for benzene in benzene–carbon tetrachloride and ethanol in ethanol–carbon tetrachloride mixtures. Results are also given for both components of the systems hexane–dodecane, ethanol–benzene and ethanol–methanol. These data were based on the observation of proton resonance in one or both components of the mixtures as applicable. Graphical techniques were used to calculate the self-diffusion coefficients from the systems containing only one resonant component. The modified Gauss-Newton nonlinear optimization technique was used to fit the NMR data from the two resonant component systems to a 3-parameter mathematical model. The three parameters were the fraction of the spin echo signal contributed by one of the components and the two self-diffusion coefficients. The computation techniques involved the determination of local minima in the sum of squares surface or the location of the intersections of minimum sum of squares contours derived from independent data sets. An independent study of the spin echo signal combinations in hexane–dodecane, ethanol–benzene, and ethanol–methanol mixtures was made. Signal fractions calculated from these results were also applied to the 3-parameter diffusion model to reduce the estimation process to the two parameters $D_1$ and $D_2$. The accuracy of the self-diffusion coefficients obtained ranged from 3 to 10% depending on the computation techniques used. Several correlations between mutual and self-diffusion coefficients were applied to the data and evaluated. (auth)

**1317** (JUL-363-ST) MESSUNG DER ADSORPTION-SEIGENSCHAFTEN VERSCHIEDENER FILTER FUER GASFOERMIGES JOD. (Measurement of the Adsorption Characteristics of Various Filters for Gaseous Iodine). Vogt, K. J.; Meringdal, J. (Kernforschungsanlage, Juelich (West Germany). Zentralabteilung Strahlenschutz). Mar. 1966. 44p. Dep. mn.

Various active C filters (active C granulated cartridges, active C paper filters, and aerosol filters coated with active C powder) were investigated with respect to their adsorption for gaseous iodine $I_2$. An exponential dependence of the permeability on the active C surface coating of the filter was found. The mass adsorption coefficient is an exponential function of the flow velocity. The adsorption capacity and decrease of the filter efficiency with increasing preliminary charge of the active C with I for foreign gases were measured. For practical application as a filter in air monitoring installations the filter media tested were found to be suitable. Active C in suitable design of the filter installation can be used as purification filters. The results of the investigations permit the optimum regulation of the active C coating and the diameter of the filter, the flow velocity, or the volume throughput, and the filter life. In very impure air the use of granulated cartridges with sufficiently high active C masses is recommended in order to obtain a high adsorption capacity. Aerosols can be separated by a preliminary filter. Under normal contamination ratios of the air, such as in free atmosphere, continuous monitoring with filter band devices offers technical advantages. The normal filter installation can be made applicable for I measurements in which the absolute filter used for normal aerosols was covered with active C powder. The active C paper filters No. 508 and 509 are not manufactured in the length suitable for filter bands. They are suitable only for fixed filter installations. (tr-auth)

**1318** (JUL-375-ST) EIN AUTOMATISCHER OBERFLAECHENVERDAMPFER ZUR DIREKTEINDAMPFUNG VON WASSERPROBEN IN MESSCHALEN. (An Automatic Surface Evaporator for the Direct Evaporation of Water Samples in Measuring Dishes). Tzschaschel, R. (Kernforschungsanlage, Juelich (West Germany). Zentralabteilung Strahlenschutz). Apr. 1966. 43p. Dep. mn.

An automatic surface evaporator for the direct evaporation of water samples in measuring dishes is described. A purely optical feed control for the water supply is used. A converging lens focuses a filament of a small tubular lamp on the water surface; a second image forming system traces an additional image in the plane of a photoresistance and this image is displaced with the height of the water level. A detailed description of the function of this control system, the type of evaporation, and the water feed is given. The operational procedure for manual and automatic operation is outlined. (J.S.R.)

**1319** (LF-31) PREPARATION OF INSOLUBLE AEROSOLS CONTAINING MIXED FISSION PRODUCTS. Technical Progress Report. Posner, S.; Bennick, J. (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex. Dept. of Aerosol Physics). July 1966. Contract AT(29-2)-1013. 14p. (CONF-660504-3). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Industrial Hygiene Assn., Annual Conference, Pittsburgh, Pa.

The preparation of an insoluble aerosol containing mixed fission products, using an ion exchange of uranyl nitrate with montmorillonite clay is described. Ion exchange of an enriched solution of uranyl nitrate to clay particles is accomplished by adsorption. After spheroidizing by encapsulation the exchanged material is sealed in a quartz vial and irradiated for 12 hours in a thermal column of the Omega West Reactor at Los Alamos, New Mexico. Evaluation by gamma ray spectroscopy reveals the quantitative fission product inventory for the exposure period; calculation

indicated an approximate 26% uptake of uranyl ions by the clay. Results indicate this method to be feasible and practicable and future studies will include evaluation of particle size versus ion uptake, fission product build-up for various exposure times, and pilot runs of aerosolization for exposure to animals. (auth)

**1320** (MCW-1497) ELECTROLYTIC REDUCTION OF URANIUM HEXAFLUORIDE TO URANIUM METAL. Piper, R. D. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). July 1, 1966. Contract W-14-108-eng-8. 7p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Direct reduction of $UF_6$ to uranium metal was demonstrated on a laboratory scale. Introduction of $UF_6$ at the graphite anode of a cell operated at 1150°C with a molten $BaF_2-LiF-UF_4$ electrolyte produced $CF_4$ at the anode and molten uranium at the cathode. Complete recovery of the $UF_6$ was obtained. (auth)

**1321** (NP-16361) SALINE WATER CONVERSION REPORT, 1965. (Office of Saline Water, Washington, D. C.). 322p. GPO $1.50.

Research progress on saline water conversion is reported under the headings of chemical physics, biosciences, chemistry, applied science, materials, distillation, membranes, special projects, engineering services, engineering analyses, and program analysis and coordination. (M.C.G.)

**1322** (NYO-3644-10) DIVINYLBENZENE BIBLIOGRAPHY. Interim Report. Wiley, Richard H. (Hunter Coll., New York). Nov. 3, 1966. Contract AT(30-1)-3644. 96p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

One thousand one hundred and nineteen references on divinylbenzene are presented. They were collected from Beilstein and Chemical Abstracts through volume 62. (M.C.G.)

**1323** (ORNL-3994, pp 53-64) ORGANIC CHEMISTRY. (Oak Ridge National Lab., Tenn.).

A study was made of the rate at which carbonium ions interconvert as compared with the rates at which they react with entering groups or eject protons to form products in a system known to proceed through classical ionic intermediates. Carbon-14 labeling and NMR spectroscopy were used to circumvent the need for extraordinary experimental precision. The concept that "internal return in carbonium ion processes necessarily alters the product ratios" was studied both mathematically and chemically and shown to be incorrect. The mechanism by which hydrogens migrate during solvolysis reactions of the norbornyl system was partially elucidated. Three rearranged products were formed when 2-exo-hydroxy-2-phenyl-3-exo-norbornyl-5,6-exo-$d_2$ tosylate was treated with boiling acetic acid. The deuterium distribution in these products was determined, and the relation of the acetolysis and hydrolysis reactions was studied. Data are presented showing how 2-phenylnorbornane-2,3-cis-exo-diol-5,6-$d_2$ reacts, when treated with concentrated sulfuric acid, to give 3-endo-phenylnorbornanone-exo-5-anti-7-$d_2$, a result of intramolecular rearrangement involving a stereospecific migration of deuterium. The deamination of 3-endo-amino-2-exo-phenyl-norbornanol-2 in glacial acetic acid led to the production and isolation of six compounds in approximately 85% yield. These products were identified either completely or partially by interpretation of their NMR spectra and by independent syntheses. The mechanistic significance of these data is discussed briefly. It was shown that during the hydrolysis of 2-exo-hydroxy-2-phenyl-3-exo-norbornyl tosylate, one of the products, 2-exo-phenylnorbornane-2-endo-5-exo-diol, is formed as a result of two consecutive 1,2 hydride shifts. 2-Ethyl-hexanohydroxamic acid was prepared and tested as a solvent for cations in equilibrium distribution studies. With this hydroxamic acid, a selectivity for zirconium, niobium, and hafnium over cobalt, uranyl, thorium, and ferric iron was found. (auth)

**1324** (ORNL-3994, pp 65-87) CHEMISTRY OF AQUEOUS SYSTEMS. (Oak Ridge National Lab., Tenn.).

The activity coefficient of HCl in $HCl-BaCl_2$ mixtures was studied to 175°C. At constant temperature and ionic strength the logarithm of the activity coefficient of HCl in the mixtures varies linearly with the ionic strength fraction of $BaCl_2$, in conformity with Harned's rule. The activity coefficient of $BaCl_2$ in the mixtures was calculated using the parameters describing this variation and those for the variation of the activity coefficient of $BaCl_2$ with ionic strength in pure $BaCl_2$ solutions. The solubility of $Ag_2SO_4$ was measured in 0.056, 0.109, and 0.242M $AgNO_3$ solutions in the temperature range from 25 to 150°C. It was found that the variation of the molality solubility product with ionic strength could be expressed by a single-parameter expression of the Debye-Hückel type even though, in contrast to other systems studied, the solubility of $Ag_2SO_4$ in the supporting electrolyte was at all temperatures and ionic strengths lower than the solubility in pure water. The solubility of $La_2(SO_4)_3$ was measured in 0.234, 0.471, and 0.714M $H_2SO_4$ solutions in the temperature range from 120 to 175°C. It was found that even in this case of a 3-2 valent salt the variation of the molality solubility product with ionic strength could be expressed by a single-parameter expression of the Debye-Hückel type, as found in previous studies of the solubility of $Ag_2SO_4$ in $H_2SO_4$. In addition to this parameter, the solubility of $La_2(SO_4)_3$ in water, which could not be measured in this temperature range due to hydrolysis, was calculated from the least-squares fit of the data. Accurate density measurements were made of aqueous solutions of NaCl and LiCl at 5°C and of LiCl at 35°C. The results at very low concentrations, obtained for the first time with high accuracy at temperatures other than 25°C, are not inconsistent with the Debye-Hückel limiting law. Further evidence is presented for the existence of salt-induced structure transitions in solution. The hydrolytic polymerization of Th(IV) in perchlorate media was investigated by equilibrium ultracentrifugation from 0 to 3 hydroxyls bound per thorium, n; up to n = 2.5 aggregated species were of low molecular weight and appeared to be in a chemical equilibrium with one another. A systematic study of the cation exchange behavior of elements in dilute to concentrated HBr solutions was carried out with a sulfonic acid resin. Many useful column separations may be designed from the data. The adsorption of alkali-metal ions, $Li^+$ to $Fr^+$, in HCl-water-methanol solutions was investigated with sulfonic acid cation exchangers of the polystyrene-divinylbenzene and phenol-formaldehyde types. Procedures for separating alkali elements from each other were devised from the results. The effect of the structure of quaternary ammonium cations on their thermodynamic properties in aqueous solutions was investigated by measurements of osmotic coefficients and enthalpies of dilution with solutions of several quaternary ammonium halides at 25°C. The relative partial molal entropy of the solvent, $\bar{S}_1 - S_1^0$, derived from these measurements was employed to interpret the effect of the cation on the water structure. Similar measurements on the tetra-n-alkylammonium halides were employed to obtain excess apparent molal entropies, which showed a pronounced dependence on the cation size. Calorimetric measurements of the heat of exchange of $Li^+$ with $Cs^+$ ion in several phosphonic acid-type cation exchangers indicated that "site binding" was probably the cause for the preference of the exchanger for the former over the latter ion. Salt filtration was observed when solution was forced by pressure through a porous glass (50 A average pore diameter), and rejection was enhanced by increasing the ion exchange capacity of the glass. Membranes were created dynamically by exposing bodies having pores of diameters in the range 0.1 to 5 $\mu$ to pressurized feeds containing suitable additives; these membranes frequently combine substantial salt rejections with high permeation rates, sometimes of several hundred gallons per square foot per day. Measurements of isopiestic ratios of solutions having the solute composition of seawater to NaCl solutions indicated that osmotic coefficients of seawater and its concentrates, $\phi_{SW}$, can be computed from empirical equations for $\phi_{NaCl}$ by insertion of seawater concentration in terms of ionic strength. Recent work at 25°C showed that the osmotic coefficient of sea salt solutions to saturation could be expressed very well by a Debye-Hückel term plus a power series in ionic strength, where the coefficients of the series were evaluated from measurements on pure NaCl solutions. The power series parameters for NaCl solutions to 260°C were re-evaluated using the most recent data available. By the use of the new values of the parameters, values of boiling-point elevations (BPE), minimum energies of recovery, and osmotic pressure were recalculated. The largest change was a 12% increase in BPE at 25° and 28 wt % solids. The Beckman 39137 cationic glass electrode was used in the temperature range 15 to 55°C to measure the activity of KCl solutions in the concentration range 0.01 to 2.5M. It was found that except at high salt concentrations at 15°C the agreement between the activities measured with the glass electrode and those reported from vapor pressure measurements was satisfactory. (auth)

**1325** (ORNL-3994, pp 95-105) NONAQUEOUS SYSTEMS AT HIGH TEMPERATURES. (Oak Ridge National Lab., Tenn.).

In contrast to earlier suggestions it was shown that aluminum chloride and zirconium tetrachloride form a simple eutectic system without a miscibility gap in the liquid state. In agreement with x-ray diffraction data for thermal expansion, drop-calorimetric measurements of the heat contents of potassium and thallium sulfates showed these diisomorphous salts to differ significantly with respect to the transition from an orthorhombic (pseudohexagonal) to a hexagonal crystal structure. While in potassium sulfate most of this change occurs isothermally at 584°C, the corresponding change in thallium sulfate has a very small isothermal part and is predominantly a gradual pretransitional process. The difference is attributable to the high polarizability of the $Tl^+$ ion. With the technique that allows emf measurements in molten metal–salt systems corrosive to ceramics, a study of the $Ce-CeCl_3$ and

Nd–$NdCl_3$ systems was made. A similarity in the emf results was found in contrast to the quite distinct differences in the two systems as shown by phase equilibria and electrical conductivity studies. An explanation correlating the various observations with the extent of the dissociation $M^{2+} \rightarrow M^{3+} + e^-$ is presented. The study of metal–salt miscibility in systems of divalent metals such as the alkaline earths was continued with a determination of the phase equilibria between strontium metal and its halides. As expected, the behavior of strontium was found to be intermediate between that of calcium and barium, though closer to the latter. Critical solution temperatures ranged from 1056 to 1106°C. The study of the miscibility of metals with their fluorides showed solid barium fluoride to be as much as four times as soluble in liquid barium metal as solid calcium fluoride in liquid calcium. Separation into two liquids did not occur in either system. Following the trend in miscibility, the solubility of magnesium metal in molten magnesium fluoride was found to be as low as 0.5 mole % at 1256°C, the melting point of the salt. (auth)

**1326** (ORNL-3994, pp 106-44) CHEMICAL PHYSICS. (Oak Ridge National Lab., Tenn.).

Studies of the effect of temperature on the near-infrared spectra of $CO_2$ and simple hydrogen-containing solvents ($H_2O$ and $D_2O$) were extended to include $NH_3$ (−80 to 146°C), n-hexane (−100 to 250°C), and cyclohexane (0° to 250°C). The temperature sensitivities of the five complex bands of $NH_3$, centered near 1.04, 0.93, 0.89, 0.80, and 0.65 $\mu$, are intermediate between those of the relatively sharp bands of $CO_2$ and those of the extremely broad bands of water in this spectral region. The spectra of n-hexane and cyclohexane, consisting of closely similar complex bands centered at 1.4, 1.2, 1.02, 0.92, and 0.75 $\mu$, are even less sensitive to changes of temperature and state than that of $CO_2$. These observations agree with the behavior to be expected on the basis of bond polarity, namely, C–H < C–O < N–H < O–H. The heat capacity of potassium hexaiodorhenate(IV), $K_2ReI_6$, was determined from 6 to 320°K. The Néel temperature of the magnetic system ($5d^3$ electronic configuration) was observed to be 23.7°K. Anomalous heat capacities occurred between 190 and 240°K. The entropy of $K_2ReI_6$ at 25°C was 118.16 cal $deg^{-1}$ $mole^{-1}$. Precise high-temperature relative enthalpy measurements on $KTcO_4$ revealed a lambda-type anomaly in the derived heat capacity curve. The anomaly occurred at 750°K, only 50° below the melting point. The standard enthalpy of oxidation of $K_2ReCl_6$(c) by alkaline hypochlorite solution was measured to be −152.7 ± 0.6 kcal/mole. This result, when combined with other available thermodynamic data, gives −183.0 and −141.6 kcal/mole for the enthalpy and free energy of formation of $ReCl_6^{2-}$(aq), respectively. The enthalpy of hydrolysis observed, −63.6 kcal/mole, was found to be inconsistent with the thermodynamic properties of $ReO_2 \cdot 2H_2O$ derived from the potential of the $ReO_2 \cdot 2H_2O$–$ReO_4^-$ couple given in the literature. It is suggested that the thermodynamic properties of freshly precipitated $ReO_2 \cdot 2H_2O$, as obtained in the hydrolysis measurements, differ significantly from those of the aged dioxide present in the potential measurements. A paramagnetic resonance spectrometer was designed and constructed so that samples can be gamma irradiated at 4°K and spectra observed without warming. Spectra were studied for single crystals of calcium hydroxide after irradiation with gamma rays. Two species were found in addition to the previously studied species, which was thought to be $O^-$. One of these species is a precursor of $O^-$, is stable at 4°K but disappears on warming, and is probably the OH radical. The other species is $O_2^-$, which forms when crystals containing $O^-$ are warmed to room temperature, but the spectrum can only be observed at very low temperatures. Paramagnetic resonance spectra were obtained during photolysis of liquid acetone and acetone solutions. Photolyzed acetone abstracts hydrogen from suitable donors. The radicals $(CH_3)_2\dot{C}OH$, $\dot{C}H_2COCH_3$, and a small amount of $\dot{C}H_3$ were obtained from pure acetone. With suitable alcohols in acetone solution the radicals $(CH_3)_2\dot{C}OH$, $\dot{C}H_2OH$, and $CH_3\dot{C}HOH$ were obtained. Similarly, radicals were formed from ether and from dioxane. The temperature dependence of the hydroxyl proton hyperfine interaction of $CH_3\dot{C}HOH$ was studied. A study was also made of the acid-catalyzed exchange of hydroxyl protons of $\dot{C}H_2OH$ and of $(CH_3)_2\dot{C}OH$. Also studied were the effects of water and acid on the radical yields from photolyzed solutions containing alcohols and hydrogen peroxide. The crystal structure of the hydrobromide of the alkaloid leucoxine was determined by precise x-ray analysis. All of the hydrogen atoms were located. The structure of the leucoxine ion, $C_{20}H_{22}O_5N^+$, which was previously only partly known from a preliminary characterization, was elucidated in complete detail. The absolute configuration is the same as that found by others in the related aporphine alkaloid bulbocapnine, but the twist about the central bond of the biphenyl system embedded in the molecule is 14° instead of 30°. A refinement of the crystal structure of copper ammonium sulfate hexahydrate based on neutron diffraction data confirmed the structure derived by others from x-ray analysis and yielded precise hydrogen-atom coordinates, from which the structural parameters of the water molecules, the ammonium ion, and the hydrogen bonds were derived. The bond length N–H appears to be about 1.06 A, somewhat higher than values from previous less precise neutron determinations of crystals containing ammonium ions. The O–H bonds are of normal length; the H–O–H angles are 109.3, 105.9, and 105.7°. A mathematical model for including explicitly the motion of torsional oscillators in least-squares refinement of crystal structures was developed and applied to the methyl groups in refinement of the $Cu_2(CH_3COO)_4 \cdot 2H_2O$ structure. A second crystal modification of $XeF_6$ was grown, and neutron diffraction data were obtained. The measurements disclosed that this phase is face-centered cubic with probable space group $P\bar{4}3c$ or $Fm3c$. The Oak Ridge computer-controlled x-ray diffractometer is in operation. It was programmed to perform all the basic operations required to collect data for crystal structure studies. A computer program to plot stereoscopic illustrations showing the symmetry elements of crystallographic and Shubnikov space groups is under development. The Shubnikov groups can often be used to describe the symmetry of the distribution of spin magnetic moments. The hydrogen atoms in $MnCl_2 \cdot 4H_2O$ were located precisely by neutron diffraction analysis. The resulting data were useful to other workers studying antiferromagnetism of this substance at low temperature and provided independent confirmation and refinement of the hydrogen-bonding pattern deduced from a previous x-ray analysis and electrostatic calculations. Some of the O–H bonds appeared rather short because of the effects of thermal motion. The four different H–O–H angles found vary from 104.3 to 112.4°. A three-dimensional set of x-ray diffraction intensity data were collected from a crystal of sedoheptulosan monohydrate for a projected determination of the crystal structure. The crystal structure of citric acid monohydrate was determined with neutron diffraction by using hydrogen-deuterium isomorphous replacement. A crystal of a stereospecifically deuterated isomer was found to have enantiomorphous domains. The crystal structure of $Na_7Zr_6F_{31}$ was shown to consist of $ZrF_8$ antiprisms joined in a network. Cuboctahedral cavities between antiprisms contain F and Na atoms. The x-ray diffraction study of liquid water as a function of temperature between 4 and 200°C was completed. Good agreement was obtained between calculated and observed x-ray intensity and radial distribution functions for a model based on an anisotropically expanded ice I structure. X-ray measurements on liquid carbon tetrachloride are quantitatively explained by a perturbed close packing of the chlorine atoms, which are tetrahedrally arranged around the carbon atoms. Total elastic scattering cross sections were measured in hydrogen-helium systems ($H_2$ in $^3He$, $D_2$ in $^3He$, and $H_2$ in $^4He$). The cross sections were all 42 ± 1 $A^2$ and were independent of temperature at relative velocities above ca. $1.2 \times 10^5$ cm/sec. A theoretical mechanism called "spectator stripping" was developed to treat the results of the molecular beam studies of alkali atom–halogen molecule reactions and was able to predict successfully the gross features observed. An experimental test of the model involving the scattering of Na from $Br_2$ was undertaken. The permanent-gas crossed-beam apparatus was used to survey the feasibility of studying some new reaction types. Preliminary experiments on the reactions of ozone with nitrous oxide and with atomic hydrogen were carried out. A method involving the use of time-of-flight techniques was developed for the study of collision-induced vibrational excitation and other inelastic molecular processes. A computer program was written that may be useful in the interpretation, in terms of classical mechanics, of angular distributions measured in experiments on molecular beam scattering. The program is written in two parts: the first part is used to adjust the minimum value of the interatomic potential to any desired equilibrium internuclear distance by adjusting the strength of the repulsive portion of the potential, while the second part computes the classical deflection function, the corresponding phase shift, and the angular spacing between the principal rainbow and the second-order rainbow. The ions $H_3O^+$, $HD_2O^+$, and $D_3O^+$ were observed in a mass spectrometer. The evidence strongly suggests these are due to the ionization of the corresponding neutral species, which are formed by a surface reaction. A study of the heterogeneous decomposition of acetone over platinum showed that two negative ions, $CH_3^-$ and $CH_3COCH_2^-$, and two free radicals, $CH_3$ and $CH_3COCH_2$, were present in the gas phase during the course of the decomposition reaction. Results from this study indicated that the first two steps in the decomposition are $CH_3COCH_3 \rightarrow 2CH_3 + CO$ and $CH_3 + CH_3COCH_3 \rightarrow CH_4 + CH_3\dot{C}OCH_2$. The measured ionization cross sections produced by 2.2-MeV alpha particles were found to conform well with predictions of the Born-Bethe and classical approximations for the removal of one electron from the outer shell of $H_2$, He, and Ar. However, the mass spectra of simple molecules produced by the heavy ions showed considerably less fragmentation than the mass spectra produced

by electrons of equivalent velocity. In the rare gases the electrons produced more multiple ionization than the alpha particles. These differences are contrary to expectations on the basis of the Born-Bethe approximation. Two high (>85%) transmission electron-bombardment ion sources capable of measuring partial pressures as low as $10^{-17}$ atm were designed and constructed. One ion source was designed for general use with experiments in which high sensitivity is required, while the second, a dual-electron-beam source, was designed for the study of unstable species such as excited neutral molecules, products of ion-molecule reactions, and free radicals. The electrodeposition of isotopic samples on small wires (~6 mils in diameter) was developed to circumvent two types of sample preparation problems encountered in most spectroscopy. Investigation of fragment ions that result from the formation of a vacancy in one of the inner shells of a heavy atom was extended to large molecules, namely, $C_2H_5I$ and $Pb(CH_3)_4$. The studies show that extensive ionization occurs followed by a Coulombic explosion of the aggregate ions. Even for these large molecules, decomposition into the constituent elements is essentially complete. (auth)

**1327** (ORNL-4029) DESIGN OF A CRITICALLY SAFE $^{233}U$ BATCH DISSOLVER FOR BUILDING 3019. Rom, A. M. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 13p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A critically safe small-scale $^{233}U$ dissolver system for dissolving gram quantities of $^{233}U$ was needed for the $^{233}U$ storage and distribution facility at ORNL. Criticality requirements were satisfied by limiting equipment diameters to 4 in., except for a 5-in. heating jacket on the dissolver, restricting the mass of bulk fissionable metal pieces permitted in the dissolver, and spacing the various equipment components with respect to each other and with existing equipment in the cell. The dissolver system, with its nominal 16-liter volume, can dissolve $^{233}U$ in amounts ranging from a few grams to 5 kg or more per day equally well. This 4-in. dissolver, designated S-15, supplements the Thorex dissolver S-1, which is 54 in. OD and more than 67 in. high. (auth)

**1328** (PAEC(A)IN-652(Suppl.1)) CARBON 14. A Literature Search. (Philippine Atomic Energy Commission, Manila). June 1966. 53p. Dep. mn.

References (266) are given to reports, journals, and patents published from 1957 through May 1965. The entries are arranged under the headings: biology and medicine; chemistry; geology and mineralogy; health and safety; instrumentation; isotope technology; physics; reactor technology. Separate personal author and corporate author indexes are included. (P.C.H.)

**1329** (SC-CR-66-2104) ELECTROCHEMISTRY OF SOME TRANSITION METALS AND LANTHANIDES DISSOLVED IN MOLTEN ALKALI METAPHOSPHATE. Caton, Roy D. Jr. (New Mexico Univ., Albuquerque. Dept. of Chemistry). Contracts AT(29-1)-789 and 53-2290. 113p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

For Sandia Corp., Albuquerque, N. Mex.

The performance of a silver-silver metaphosphate reference electrode was tested with respect to its reproducibility and stability. The average potential observed between two identical reference electrodes was approximately 2 mV. Electrode potential studies were conducted on the Cu(II)/Cu(I), V(V)/V(IV), and U(VI)/U(IV) systems. Plots of potential versus the logarithm of the ratios of the concentrations of the oxidation states were constructed for each system. These plots yielded straight lines in all cases. Chronopotentiometric investigations were conducted on the same solutions employed in the electrode potential studies. The method was found to be analytically useful for the determination of V(V), Ag(I), U(VI), U(VI), Cu(I), and Cu(II) (in the absence of Cu(I)). Provided care is taken in exposing a constant area of the electrode to each solution, the analyses can be performed with an accuracy of better than 3%. (P.C.H.)

**1330** (SC-DC-66-1127) THE EXPLOSION-FREE COMBUSTION OF ZIRCONIUM DROPLETS. Nelson, L. S. (Sandia Corp., Albuquerque, N. Mex.). 1966. Contract AT(29-1-789. 16p. (CONF-660447-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Spring Meeting, Western States Section, Denver, Colo.

When submillimeter zirconium droplets burn under ordinary conditions, the individual combustions almost always appear to terminate in violent fragmentations. By using either relatively large droplets or highly purified metal and oxidizers, it was found that the explosions can be eliminated, allowing study of oxidative phenomena that are obscured by the explosions. Gravimetric studies showed that as much as 45% of the total oxidation may be masked by the fragmentations. Once the explosions were eliminated, it became possible to study the following: room temperature colors of droplets quenched in the final stages of combustion; spearpointing; and rates of oxidation. (P.C.H.)

**1331** (TID-23351) EFFECTS OF GEOMETRY FOR DEPOSITION OF RADIOACTIVE MOLECULES FROM STAGNANT GAS IN CONTAINMENT VESSELS. Progress Report No. 2. Ozisik, M. Necati; Chen, Paul C. Y. (North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering). Aug. 1966. Contract AT(40-1)-3414. 38p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Effects of geometry on deposition of radioactive molecules from stagnant gas to the vessel walls are theoretically investigated for three different geometries: parallel plates, long cylinder, and sphere. In formulating the boundary value problem, it is assumed that the diffusion flux in the immediate vicinity of the wall surface is proportional to the concentration of radioactive molecules in the gas, and the effects of removal of molecules from the wall surface are also included in the boundary condition. Finite integral transform techniques are employed to reduce the coupled partial differential equations to a single integral equation. For perfect sink condition at the wall surface, analytical solutions are obtained. For imperfect sink condition, the integral equation is represented in the finite difference form, which is then solved with a digital computer for the concentration of radioactive molecules deposited on the wall surface. The general formulation of the problem for the three different geometries investigated are all represented in the same form, but they differed only through the eigen values for use in these relations. It happens that the eigen values for parallel plates are the lowest, and for sphere the highest. Thus, the quantity of deposition at any time for these three different geometries having the same characteristic length is highest for the parallel plates, and lowest for the sphere, the long cylinder having a value between them. Theoretical results of long cylinder model were compared with the experiments obtained from the deposition test performed in a Nuclear Safety Pilot Plant at the Oak Ridge National Laboratory. The agreement between the theory and the experiment was reasonably good. (auth)

**1332** (UCRL-13240) BORON HYDRIDE STUDIES. Final Progress Report. Marshall, M. D.; Hunt, R. M. (Callery Chemical Co., Pa.). Oct 1966. Contract W-7405-eng-48. 21p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

For Univ. of California Lawrence Radiation Lab., Livermore.

The laboratory phase of the preparation and purification of quaternary ammonium octahydrotriborate and dodecahydrododecaborate derivatives prepared from sodium hydride or sodium borohydride and diborane was successfully completed. Process data are presented for the production of one-half-pound batch preparations of tetramethylpiperazinium bis-octahydrotriborate (TMPOT); tetramethylpiperazinium dodecahydrododecaborate (TMPDD); 1,4-dimethyl-1,4-diaziniabicyclo [2.2.2] octane bis-octahydrotriborate (DDBOT); and 1,4-dimethyl-1,4-diaziniabicyclo [2.2.2] octane dodecahydrododecaborate (DDBDD). The process data are amenable for the production of multi-pound quantities of the boron hydrides in pilot plant equipment. Cost estimates and process information for 10-pound quantities of the boron hydrides TMPOT, TMPDD, DDBOT, and DDBDD have been completed. (auth)

**1333** (UCRL-17069) NUCLEAR MAGNETIC RESONANCE STUDY OF WATER EXCHANGE FROM THE FIRST COORDINATION SPHERE OF Gd(III) ION. Marianelli, Robert (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1966. Contract W-7405-eng-48. 92p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Thesis.

The temperature and frequency dependence of the width, $(1/T_2)$, of the $^{17}O$ NMR signal in an aqueous solution of gadolinium ions was studied in the range from 0 to 100°C at 2.000, 4.000, 5.772, and 8.134 Mc. The temperature study at 8.134 Mc was extended to −58°C by means of a $H_2O-HClO_4$ eutectic solution (40.7% $HClO_4$ by weight). The temperature dependence of the $^{17}O$ longitudinal relaxation rate, $(1/T_1)$, of water both in the presence and absence of Gd(III) ion was studied in the range from 0 to 100°C at 8.134 Mc. The temperature dependence of the width, $(1/T_{2e})$, of the ESR spectrum of Gd(III) ions in aqueous solutions was studied in the ranges from 20 to 145°C and 20 to 100°C at 9,180 and 24,250 Mc, respectively. The width of the ESR spectrum is interpreted in terms of the zero field splitting of the gadolinium ion modulated by rotation and inversion of the $Gd(H_2O)_8^{3+}$ complex. The width of the bulk water $^{17}O$ NMR spectrum is controlled by the rate of transverse relaxation in the first coordination sphere of the Gd(III) ion. This in turn is a result of the scalar coupling and dipole-dipole interactions between the electron spin of the Gd(III) ion and the nuclear spin of the $^{17}O$ nucleus. The ESR results coupled with proton relaxation times in aqueous solution of Gd(III) and the $^{17}O$ NMR results lead to a determination of the rate constant and its temperature dependence for the chemical exchange of bulk water molecules with those in the first coordination sphere of Gd(III) ion. The previously observed anomaly of the high to low magnetic field ratio of

the proton transverse relaxation time can be explained by dipole-dipole coupling interrupted by electron spin relaxation as well as tumbling, using Solomon's equations. (auth)

**1334** (LA-tr-66-64) PRESSURE EFFECT ON THE FORMATION OF COMPOUNDS IN THE $Y_2O_3-Al_2O_3$ SYSTEM. Naka, Shigeharu; Takenaka, Osamu; Sekiya, Tadashi; Noda, Tokiti. Translated for Los Alamos Scientific Lab., N. Mex., from Kogyo Kagaku Zasshi, 69: 1112-16(1966). 10p. Dep. mn. JCL $1.60 fs, $0.80 mf.

The effect of pressure on the formation of compounds in the $Y_2O_3-Al_2O_3$ system was examined and the products were compared with those formed under normal pressure. Under normal pressure, garnet of the composition $3Y_2O_3 \cdot 5Al_2O_3$, perovskite of the composition $Y_2O_3 \cdot Al_2O_3$, and a monoclinic compound were formed most readily. In addition to perovskite, both garnet and a monoclinic compound were found in the products of the composition $Y_2O_3 \cdot Al_2O_3$ when heat treatment was applied at 1500°C (to the raw material). Fusion treatment (of the raw material), however, gave rise to a single phase of perovskite, which partially decomposed at 1500°C after 24 hours to yield a garnet and a monoclinic compound. A sample in gel form gave garnet as a major product at 5 kb and 400°C. A sample having more $Al_2O_3$ than the composition $3Y_2O_3 \cdot Al_2O_3$ does contained boehomite and YOOH (together with garnet), while a sample having more $Y_2O_3$ (than the composition $3Y_2O_3 \cdot 5Al_2O_3$ does) was found to have YOOH (together with garnet). The lattice constant of garnet produced under high pressure was 12.03 to 12.04Å, while the lattice constant of garnet formed under normal pressure was 12.004Å. The high-pressure garnet was probably garnet solid solution of the $(Y_3)\ Y_xAl_{2-x} \cdot (Al_3)\ O_{12}$ type. This garnet solid solution was stable at 1000°C under normal pressure. (auth)

**1335** SPECTRAL STUDIES ON STEROIDAL NITRATE ESTERS. I. INFRARED INVESTIGATIONS IN THE 680- TO 1800-$cm^{-1}$ REGION. Hodosan, Francisc; Jude, Ioan (Inst. of Chemistry, Cluj). Rev. Roum. Chim., 11: 983-91(Aug. 1966).

The characteristic bands of twenty-one steroidal nitrate esters were identified and their assignment verified by comparison with the spectra of certain $^{15}N$-labeled nitrates. It was proved that the band around 700 $cm^{-1}$ was erroneously ascribed to the $NO_2$ bending mode of vibration. Attempts were made to correlate the characteristic features of the spectra with certain steric and structural factors. (auth)

**1336** SPECTRAL STUDIES ON STEROIDAL NITRATE ESTERS. II. INFRARED ABSORPTION OF COMPOUNDS WITH TWO ADJACENT $ONO_2$ GROUPS. Hodosan, Francisc; Jude, Ioan (Inst. of Chemistry, Cluj). Rev. Roum. Chim., 11: 993-8(Aug. 1966).

Conformationally homogeneous cyclic compounds with two adjacent $ONO_2$ groups that are gauche to each other show $NO_2$ antisymmetric stretching vibration ($\nu asNO_2$) and $NO_2$ symmetric stretching vibration ($\nu sNO_2$) frequencies equal to those ascribed by Urbánski and Witanowski to the gauche form of simple aliphatic 1,2-dinitrates. The presumed rotational isomerism of the latter is thus confirmed. The effect of labeling with $^{15}N$ as well as that of crystalline state is reported. (auth)

**1337** STUDIES ON URANYL CHLORIDES. I. THERMAL STABILITY AND IR SPECTRA OF URANYL TETRACHLORIDE SALTS WITH ALKALI METALS. Ripan, Raluca; Mirel, Constantin (Chemische Institut, Cluj). Rev. Roum. Chim., 11: 805-7(July 1966). (In German).

The increases in the thermal stability and the changes in the infrared spectra of various uranyl tetrachloride salts (Li–Cs) were investigated. (tr-auth)

**1338** ACCELERATING EFFECT OF IODINE ON THE OXIDATION OF NUCLEAR GRAPHITE BY CARBON DIOXIDE. Yamauchi, S.; Mukaibo, T. (Tokyo Univ.). Carbon, 4: 455-6 (Oct. 1966).

As part of a study on the effects of $I_2$ on the oxidation of graphite by $CO_2$, the dependence of the oxidation rate on the pressure of $I_2$ was investigated. It was found that the oxidation rate increased gradually with an increase in $I_2$ pressure. Equations are given for the adsorption-pressure relation. (J.G.B.)

**1339** THE OXIDATION OF TUNGSTEN AT HIGH TEMPERATURES. THE SYSTEM W + $CO_2$. Gismaru, D.; Geangu-moisin, A. (Centre of Physical Chemistry, Academy of the Socialist Republic of Romania, Bucharest). Rev. Roum. Chim., 11: 777-82 (July 1966).

Studies were made on the oxidation of tungsten from 500 to 1000°C in a $CO_2$ atmosphere at pressures of 0.187, 0.42, and 1 atm. The results obtained showed that the oxidation is governed by the equilibrium conditions of the systems produced by the initial system W + $CO_2$. The process takes place according to a parabolic law in the whole temperature and pressure range. The rate constants found for the $CO_2$ pressure of 0.187 atm allowed the determination of the activation energy between 500 and 1000°C (4535.5 cal/mole). The rate constant values are lower than those obtained by other authors under similar conditions of temperature and pressure. The effect of the $CO_2$ pressure was marked by the increase of the oxidation rate. (auth)

**1340** INVESTIGATION OF HYDROLYSIS PRODUCTS FROM URANIUM TRIOXIDE AND URANYL SALTS BY DERIVATOGRAPHY AND INFRARED SPECTROSCOPY. Fodor, M.; Poko, Z.; Mink, J. (Central Research Inst. for Physics, Budapest). Mikrochim. Acta, No. 4-5, 865-85(1966).

Hydrolysis of $\beta$- and amorphous $UO_3$ was studied by infrared spectroscopy and thermogravimetry at room temperature; uranyl salts in the presence of anion exchange resins were also studied. Compounds of $UO_3 \cdot 2H_2O$ composition with identical properties were found with a trimeric formula or an integral multiple of a trimeric form. Water molecules are present in two kinds of bonds. One kind of water has diffuse bond strength and is probably water between individual layers, whereas the other is a structural water of definite bond strength, which may form various hydrogen bridge bonds. (auth)

**1341** DEUTERIUM ISOTOPE EFFECTS ON HYDROGEN BONDING. Singh, Surjit; Rao, C. N. R. (Indian Inst. of Tech., Kanpur). Can. J. Chem., 44: 2611-15(Nov. 15, 1966).

The interaction of phenol and phenol-d with a number of donors of varying basicity was studied in terms of the equilibrium constants, $\Delta S^0$, $\Delta H^0$, $\Delta\nu_{OH}$, and $\Delta\nu_{OD}$. Various aspects of deuterium isotope effects on hydrogen bonding are discussed. The deuterium isotope effects were found to vary markedly with the basicity of the donor and the results are discussed in terms of the zero point contributions to the $K_H/K_D$. (auth)

**1342** PREDICTION AND MEASUREMENT OF EFFECT OF CHELATING SELECTIVITY ON PRECIPITATION REACTIONS. Kelly, John J.; Sutton, Doris C. (Atomic Energy Commission, New York). Talanta, 13: 1573-85(Nov. 1966).

A theoretical treatment of precipitation equilibrium in the presence of a chelating agent was expanded to include the common ion effect on precipitation reactions. The extent of precipitation can be predicted over the full range of pH for any metal for which the solubility product of the precipitate and the stability constants for a complex are known. The expanded equation was used in this investigation to predict the extent of precipitation for several metals in the presence of ethylenediaminetetraacetic acid (EDTA) with common precipitants such as hydroxide, oxalate, sulfate, sulfide, and 8-hydroxyquinoline, but may be applied to any system containing other chelating agents. The limits of precipitation in terms of pM′, the negative logarithm of the concentration of unprecipitated metal ion, are presented graphically as a function of pH for a system containing fixed amounts of precipitating and complexing agents. Measurements for observed reactions at two pH levels, 5 and 10, are compared with the calculated predictions of the equation. Thirty-five metals were investigated. (auth)

**1343** STUDIES ON COAGULATION AND ELECTRICAL PROPERTIES OF THORIUM FERROCYANIDE, THORIUM SUCCINATE, AND COBALT FERROCYANIDE HYDROSOLS. Sanyal, Nirendra Nath; Kundu, Nityananda (Raja Pearymohan Coll., Uttarpara, Hooghly, India). J. Indian Chem. Soc., 43: 485-8(July 1966).

The corrected $\zeta$-potentials of thorium ferrocyanide, thorium succinate, and cobalt ferrocyanide sols were determined taking surface-conductance effect into consideration. The coagulation phenomena were explained in the light of the equation: $\zeta_a = A + B \log \Sigma C_i$ where $\zeta_a$ represents the $\zeta$-potential of the sol at a total equicoagulating concentration of $\Sigma C_i$ of counter ions in normality and A and B are constants. The limiting concentrations of the counter ions, beyond which surface-conductance effect vanishes, were calculated for the sols. (auth)

**1344** REACTIONS IN SOLUTION IN $BrF_3$. THE U–ALKALINE FLUORIDES. Chretien, Andre; Martin, Dominique (Laboratoire de Chimie Minerale, Paris). Compt. Rend., Ser. C, 263: 235-8(July 18, 1966). (In French).

The neutralization of the base M $[BrF_4]$ (M = Na, K, Rb, or Cs) by the anhydride $UF_4$ in $BrF_3$ is detected by cryoscopy and by electric conductivity. This neutralization is shown only at one stage. The corresponding U/M ratio is 1 for Na and Rb, 1.66 for K, and 2 for Cs. The salt obtained fixes the anhydride by addition for Cs. Some alkaline uranium fluoride complexes were obtained, two for Cs. Those of Na and K are insoluble in $BrF_3$. (tr-auth)

**1345** THE $A^1\Sigma-X^1\Sigma$ TRANSITION OF $^{39}KH$ AND $^{39}KD$. VIBRATIONAL NUMBERING AND MOLECULAR CONSTANTS. Bartky, Ian R. (National Bureau of Standards, Washington, D. C.). J. Mol. Spectros., 20: 299-311(Aug. 1966).

The absorption spectrum of KD was observed in the 5100 to

5200 Å region. An analysis of the spectrum in this region showed that previous assignments of the KD and KH spectra are in error. The v'-numbering of KD must be increased by 3, and the J-numbering of the P and R branches must be decreased by 1; the v'-numbering of KH must be increased by 2. Re-analysis of the existing data on KH and KD gave a consistent set of vibrational and rotational constants for the states of these molecules. (auth)

**1346** KINETICS OF HYDROGEN ABSTRACTION FROM PROTON DONORS BY DPPH. Singh, Surjit; Bhaskar, K. R.; Rao, C. N. R. (Indian Inst. of Tech., Kanpur). Can. J. Chem., 44: 2657-62(Nov. 15, 1966).

The kinetics and energetics of the interaction of diphenylpicrylhydrazyl (DPPH) with a variety of hydroxylic compounds were investigated by electronic and ESR spectroscopy. Deuterium isotope effects on the kinetics have been examined. A model involving hydrogen bonded complexes has been suggested for the hydrogen abstraction reaction. (auth)

**1347** REPORT ON NINE TECHNICAL AND ECONOMIC STUDIES ON THE UTILIZATION OF RADIOACTIVE ISOTOPES IN THE CHEMICAL AND PETROLEUM INDUSTRIES. Wieczorek, H.; Wiesner, L. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), Suppl., No. 61, 5-10(Sept.–Oct. 1966). (In French).

Nine specific examples of the use of radioisotopes for filling, density, and humidity measurements in the chemical and petroleum industries are given and their economic impact evaluated. (J.S.R.)

**1348** KINETIC HYDROGEN ISOTOPE EFFECTS IN THE IONIZATION OF SOME NITROPARAFFINS. Bell, R. P.; Goodall, D. M. (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 294: 273-97(Oct. 4, 1966).

Values are reported for the kinetic hydrogen isotope effects for proton-transfer reactions between hydroxide ions and nitromethane, nitroethane, nitrocyclohexane, and 2-nitropropane, and between 2-nitropropane and pyridine, 2,6-lutidine and acetate ions. In conjunction with earlier work the results suggest that the isotope effect has a maximum value for proton transfers between two acid-base systems of approximately equal pK, in agreement with theoretical predictions. It was confirmed that the abstraction of a proton from 2-nitropropane by 2,6-lutidine exhibits an abnormally high isotope effect ($k^H/k^D = 20$), probably attributable to a considerable tunnelling correction. (auth)

**1349** PARTITION FUNCTION RATIOS OF ISOTOPIC ALKALI HALIDES. Ishida, Kenji (Japan Atomic Energy Research Inst., Tokyo). J. Nucl. Sci. Technol., (Tokyo), 3: 355-6(Aug. 1966).

Using the vibrational frequencies of alkali halide molecules, the partition functions at 25°C were calculated. The relationships of force constant and partition function rate, force constant and ionic dissociation energy, and ionic dissociation energy and partition function ratio were studied. A study of the dependence of masses of alkali isotopes on partition function ratio and dependence of mass of halogen atom on partition function ratio was made. (D.H.M.)

**1350** POSSIBILITY OF STUDYING HOMOGENEOUS ISOTOPIC EXCHANGE WITHOUT SEPARATING THE COMPONENTS. Gosman, A.; Soldatov, E. A. (Moscow State Univ. Czechoslovak School of Higher Technical Education, Prague). Dokl. Akad. Nauk SSSR, 167: 373-5(Mar. 11, 1966). (In Russian).

A diffusion method is proposed to determine the rate of isotopic exchange R. One of the exchange compounds is labeled with a radioactive isotope, and placed in a capillary which is closed at one end. The open end of the capillary is placed in a vessel of large volume containing an unlabeled solution of the same composition. Diffusion from the capillary takes place simultaneously with isotopic exchange in the capillary so that the activity of the solution in the capillary decreases with time. The rate of activity decrease is determined by the diffusion coefficients of the exchange compounds ($D_1$ and $D_2$) and by the rate of isotopic exchange R. The set of differential equations describing the processes in the capillary are as follows: 1) $\delta C_1/\delta t = D_1 \delta^2 C_1/\delta x^2 - k_1 C_1 + k_2 C_2$, and 2) $\delta C_2/\delta t = D_2 \delta^2 C_2/\delta x^2 - k_2 C_2 + k_1 C_1$. Here $C_1(x,t)$ and $C_2(x,t)$ are the concentrations of labeled molecules of the exchange compounds; l is the capillary length; $k_1 = R/C_1^0$ and $k_2 = R/C_2^0$, where $C_1^0$ and $C_2^0$ are the concentrations of exchange compounds. In the above equations the first term on the right describes the change in concentration of labeled compound due to diffusion, and the second term gives the change in concentration due to exchange. This equation is solved to give an expression for the ratio of the total activity in the capillary to the initial activity $I/I_0$. A plot of log $(I/I_0)$ as a function of time gives a straight line, whose intercept with the ordinate gives the value of the rate of isotopic exchange R. (TTT)

**1351** DIELECTRIC POLARIZATION OF CRYSTAL HYDRATES OF VARIOUS URANYL COMPOUNDS. Baranova, L. I.; Syrkin, Ya. K.; Shchelokov, R. N. (Kurnakov of General and Inorganic Chemistry, Academy of Sciences, USSR). Zh. Strukt. Khim., 7: 124-5(Jan.-Feb. 1966). (In Russian).

It was previously shown that the nature of the bond of water in hydrated crystals may be determined from the effective polarization of water. In order to examine the effect of the type of the cation on the $P_{eff}$ of the water of crystallization, the dielectric polarization of the hydrates of the complexes $K_2UO_2(CrO_4)_2$ and $(CN_3H_6)UO_2(C_2O_4)_2$ were studied at 25°C and 1 MHz by dehydrating the hydrated crystals in a vacuum desiccator over $P_2O_5$. The $P_{eff}$ of $K_2UO_2(C_2O_4)_2$ was found to amount to about 8 $cm^3$, or the same value as that of the corresponding Na salt. The $P_{eff}$ of the guanidine compound was high, indicating that the water was structurally bound in the lattice voids; similar results were obtained with the aniline derivative. In order to explain these results, it was assumed that the compounds contain layers of the composition $[UO_2(CO_2O_4)_2]$, as in minerals. Ions and water molecules are probably located around these layers. The water may be coordinated by the cations or may form linkages between the O atoms of the oxalate in neighboring groups. Introduction of weakly polarized large organic cations of guanidine and aniline increases the distance between the layers. This assumption is supported by the fact that the coordination polyhedron $[UO_2(C_2O_4)_2(H_2O)_2]^{2-}$ is not stable; the highest packing density is reached at a $U-H_2O$ distance of 2.6Å. (TTT)

**1352** A LARGE "STERIC" SECONDARY HYDROGEN ISOTOPE EFFECT IN THE E1 DEGRADATION OF A QUATERNARY AMMONIUM SALT. Cooper, G. H.; McKenna, J. (The Univ., Sheffield, Eng.). Chem. Commun., No. 20, 734-5(Oct. 19, 1966).

A large normal isotope effect is reported for the E1 degradation of 5α-cholestan-6β-yl trimethylammonium iodide and the tris-trideuteromethyl analog. The first order rate constants for the degradation in ethanol at 70°C for these salts to cholest-5-ene and $N(CH_3)_3HI$ or $N(CD_3)_3HI$ are $6.4 \times 10^{-5}$ and $4.0 \times 10^{-5}$ $sec^{-1}$, respectively, giving $k_H/k_D = 1.6$. The isotope effect is described as steric in origin and not primarily due to the different inductive effects of H and D. (B.L.M.)

**1353** ORGANIC COMPOUNDS OF URANIUM. II. REACTIONS OF URANIUM TETRACHLORIDE WITH FATTY ACIDS. Bhandari, A. M.; Kapoor, R. N. (Univ. of Jodhpur, India). Z. Anorg. Allg. Chem., 346: 332-6(Sept. 1966).

Reactions of uranium tetrachloride with excess fatty acids (acetic, propionic, lauric, myristic, palmitic, and stearic) in anhydrous benzene were found to yield tetra derivatives of uranium. These derivatives were purified and crystallized from hot benzene. Tetraacylates of uranium were quantitatively precipitated by the reaction of uranium tetrachloride with an excess of sodium salts of fatty acids (lauric, myristic, palmitic, and stearic) in aqueous solution. Attempts to prepare mixed chloride acylates were unsuccessful. Melting points of these acylates are reported. (auth)

**1354** HEATS OF FUSION AND TRANSFORMATION FOR SOME METALS AND COMPOUNDS. Chiotti, Premo; Gartner, G. J.; Stevens, E. R.; Saito, Yasutoshi (Iowa State Univ., Ames, Iowa). J. Chem. Eng. Data, 11: 571-4(Oct. 1966). (IS-1263).

The heats of fusion and allotropic transformation for Ca, Ce, Mg, Pb, Sn, Zn, $CaMg_2$, $MgZn_2$, CeZn, $CaZn_2$, $CaCl_2$, and $ThCl_4$ were measured with an adiabatic calorimeter and the results presented. (auth)

**1355** SPECTROPHOTOMETRIC STUDY OF COMPLEXES OF CERTAIN ELEMENTS WITH METHYLTHYMOL BLUE. Tikhonov, V. N. (All-Union Scientific-Research Aluminum–Magnesium Inst., Berezniki, USSR). Zh. Anal. Khim., 21: 1172-8(1966). (In Russian).

Complexes of certain elements (Fe, Ga, In, Th, Ti, V, and Zr) with methylthymol blue were studied spectrophotometrically. Absorption spectra were obtained, and the effects of pH and the amount of reagent were studied. Composition of the complexes was established. The effects of common anions and frequently used masking agents were also investigated. (auth)

**1356** CRYSTAL STRUCTURE OF AMMONIUM PENTAFLUOXYURANATE. Brusset, H.; Gillier, H.; Nguyen Quy Dao (Ecole Normale Superieure, Paris). Bull. Soc. Chim. France, No. 7, 2396(July 1966). (In French).

The reaction of an excess of ammonia with a uranyl fluoride solution produces a precipitate that disappears on prolonged boiling. Cooling of the solution causes the appearance of a precipitate, that crystallizes from aqueous solution as fluorescent prismatic crystals with the chemical formula $(NH_4)_3UO_2F_5$. The crystals present well-defined facets under microscopic examination. The crystal is assigned to an orthorhombic pseudo-lattice with the parameters $|\vec{a}'| = 9.74 \pm 0.01$, $|\vec{b}'| + 9.48 \pm 0.01$, and $|\vec{c}'| = 9.38 \pm 0.001$. Examination of very low intensity reflections showed that the true cell is

monoclinic with the binary axis oriented along the b′ axis of the orthorhombic pseudo-lattice. (J.S.R.)

**1357** SECONDARY ISOTOPIC EFFECT OF DEUTERIUM. Laszlo, Pierre; Welvart, Zoltan (CNRS, Gif-sur-Yvette, France). Bull. Soc. Chim. France, No. 7, 2412-38(July 1966). (In French).

A review is given of the secondary isotopic effect of deuterium in organic chemical reactions in the liquid phase. The various preponderant manifestations of the secondary isotopic effect and the applications to the study of reaction mechanisms are the topics discussed. (207 references). (J.S.R.)

**1358** THE DETERMINATION OF DISTRIBUTION COEFFICIENTS AND STABILITY CONSTANTS OF COMPLEXES OF NICKEL AND URANIUM WITH QUADRIDENTATE SCHIFF BASES. RADIOTRACER STUDIES ON THE EXTRACTION OF METAL IONS. XI. Stronski, Ignacy; Zielinski, Andrzej; Samotus, Alina; Stasicka, Zofia; Budesinsky, Bretislav (Inst. of Nuclear Physics, Krakow. Jagellonian Univ., Krakow. Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Z. Anal. Chem., 222: 14-22(1966).

The influence of the pH of the electrolyte on the distribution coefficients of Ni and U chelates with some aromatic Schiff bases was investigated. It was found that Schiff bases could be used for the extraction of small quantities of $Ni^{2+}$ and $UO_2^{2+}$ ions. The dissociation constants of the Schiff bases, bis-salicyladehyde-ethylenediimine, bis-3-methoxysalicylaldehyde-ethylenediimine, and bis-salicylaldehyde-phenylenediimine were determined by the spectrophotometric method; and the UV absorption spectra of these complexing compounds were measured in buffer solutions of pH 2 and 12. The stability constants of $Ni^{2+}$ and $UO_2^{2+}$ chelates with these Schiff bases were determined by means of Dyrssen and Sillen's two-parameter approximation. (auth)

**1359** INFRARED STUDIES ON GLYCINE AND ITS ADDITION COMPOUNDS. Khanna, R. K.; Horak, M.; Lippincott, E. R. (Univ. of Maryland, College Park). Spectrochim. Acta, 22: 1759-71(Oct. 1966).

The infrared absorption spectra of glycine, mono- and diglycine hydrochlorides and hydrobromides, their deuterated analogs and the ones containing $^{15}N$-substituted glycine were investigated from 3500 to 250 $cm^{-1}$ at room temperature and at liquid $N_2$ temperature. The spectra of the equilibrium mixtures containing the species $NH_3^+CH_2COO^-$, $NH_2^+DCH_2COO^-$, $NHD_2^+CH_2COO^-$, and $ND_3^+CH_2COO$ were discussed in terms of the vibrational modes of the groups $NH_3^+(NH_2D^+, NHD_2^+, ND_3^+)$, $CH_2$, $COO^-$, and the skeleton $CCN^+$ in the light of the effect of the coupling of vibrations on the absorption characteristics. The region 3200 to 1800 $cm^{-1}$ shows bands that seem to represent characteristic $N^+-H \ldots O/N^+-D \ldots O$ bond properties and the Fermi resonance between $N^+-H(N^+-D)$ stretch and the overtones/combinations (believed to be the cause of the complexity of this region) does not appear probable as revealed by the deuteration studies. The spectra of monoglycine hydrochloride and hydrobromide indicate a dimer formation between two glycinium units ($NH_3^+CH_2COOH$) through very strong hydrogen bonds ($O-H \ldots O$). The spectral data on diglycine hydrochloride and hydrobromide are consistent with the reported crystal structure. (auth)

**1360** INFRARED STUDIES ON SOME FERROELECTRIC COMPOUNDS OF GLYCINE. Khanna, R. K.; Horak, M.; Lippincott, E. R. (Univ. of Maryland, College Park). Spectrochim. Acta, 22: 1801-11(Oct. 1966).

The infrared absorption spectra of monoglycine nitrate, diglycine nitrate, triglycine sulfate, their deuterated and $^{15}N$ (glycine and $HNO_3$) substituted analogs have been investigated at room temperature and at liquid $N_2$ temperature. These data suggest the nature of the binding between the polyatomic units in the respective crystal lattices. A switching mechanism in the ferroelectric phase of diglycine nitrate is proposed. The data on triglycine sulfate are consistent with the reported crystal structure and the proposed switching mechanism. There was no indication of any phase transition in monoglycine nitrate between room temperature and liquid $N_2$ temperature. (auth)

**1361** INFRARED SPECTRA OF [1,4-$^{13}C_2$]-CYCLOHEXANE-(1,4)DIONE AND [1,4-$^{13}C_2$]-1,4-BENZOQUINONE. Doepp, D.; Musso, H. (Univ., Marburg, Ger. Ruhr-Univ., Bochum, Ger.). Spectrochim. Acta, 22: 1813-22(Oct. 1966). (In German).

The shifts of infrared frequencies of [1,4-$^{13}C_2$]-cyclohexane-(1,4)dione and [1,4-$^{13}C_2$]-p-benzoquinone in the solid state, in solution, and in the vapor phase are discussed in relation to band assignments. (auth)

**1362** COBALT(III)-CATALYZED DEUTERIUM EXCHANGES ON LIGANDS WITH GLYCINATE RINGS. Terrill, James B.; Reilley, Charles N. (Univ. of North Carolina, Chapel Hill). Inorg. Chem., 5: 1988-96(Nov. 1966).

Isotopic exchange in acidic heavy water of cobalt(III) polyaminocarboxylic acid chelates containing glycinate ring structures was followed by nuclear magnetic resonance spectroscopy by observing decreases in spectral intensities. The exchange process, occurring by pseudo-first-order decay, was studied in the acidity range from 0.05 to 0.5M acid at 85, 95, and 103°C. Intermediate isotopic enantiomeric species were observed to be formed at the out-of-plane methylene carbon while the in-plane methylene protons did not undergo direct isotopic exchange. A major consideration in elucidating various features of the exchange process was the stereochemistry of the individual ligand. An enol intermediate was proposed for the exchange mechanism. (auth)

**1363** MECHANISTIC STUDIES IN STRONGLY BASIC MEDIA. PART III. BIFLUORENYLIDENE FORMATION FROM 9-BROMO-9,9′-BIFLUORENYL. Bethell, D.; Cockerill, A. F. J. Chem. Soc., B, No. 9, 917-20(1966).

9-Bromo-9,9′-bifluorenyl undergoes E2 elimination in t-butyl alcohol solution containing hydroxide, methoxide, or t-butoxide ions, or piperidine to form bifluorenylidene. Comparison of the rate with that for elimination of deuterium bromide from 9-bromo-9′-deutero-9,9′-bifluorenyl leads to $k_H/k_D$ values greater than predicted from the difference of zero-point vibrational energy for the stretching of the tertiary C−H and C−D bonds in the halides. An earlier conclusion concerning the mechanism of conversion of 9-bromofluorene into bifluorenylidene in basic media has been confirmed. (auth)

**1364** REACTIONS OF ACTIVE NITROGEN WITH ETHYLENE AND DEUTERATED ETHYLENES. Foster, Kenneth D.; Kebarle, P.; Dunford, H. B. (Univ. of Alberta). Can. J. Chem., 44: 2691-2701(Nov. 15, 1966).

The reactions of active nitrogen with ethylene and deuterated ethylenes were investigated using a mass spectrometer. The rate of disappearance of atomic nitrogen in the presence of ethylene appears to obey the equation: $-d[N]/dt = k_{app}[N]\,[\text{ethylene}]_0$, where $k_{app}$ is an apparent second order rate constant and $[\text{ethylene}]_0$ is the initial concentration of added ethylene. However, exceptions to this equation are found at 0.6 Torr either for short reaction times or for small concentrations of added ethylene, and apparently for short reaction times at 2.6 Torr when a large excess of ethylene is added. Where the above equation is obeyed, $k_{app} = (3 \pm 1) \times 10^{-13}$ cc molecule$^{-1}$ s$^{-1}$. The formation of $C_2D_4$ in the reaction of active nitrogen with $C_2D_3H$ is interpreted as further evidence for the importance of hydrogen atom reactions in intermediate steps of the reaction of active nitrogen with ethylene. (auth)

**1365** ABSORPTION SPECTRUM OF SH AND SD IN THE VACUUM ULTRAVIOLET. Morrow, B. A. (National Research Council, Ottawa, Ont.). Can. J. Phys., 44: 2447-60(Oct. 1966).

The absorption spectrum of SH in the vacuum ultraviolet was obtained by the flash photolysis of hydrogen sulfide. Transitions from the $^2\Pi$ ground state to seven excited states were observed and four of these fit reasonably well into a Rydberg series. From an extrapolation to the convergence limit of this series, a value of 10.40 ± 0.03 eV for the ionization potential of SH was derived. Values for the rotational constants of these new electronic states were determined; corresponding data for SD were also obtained. The (1-0) transition of the system near 1 670 Å ($B\,^2\Sigma - X\,^2\Pi$) was observed, and, with the aid of isotope relations, vibrational constants of the B state were derived. An estimate of the dissociation energy of SH in this excited state is $D_0' = 24{,}190 \pm 1{,}000$ $cm^{-1}$. (auth)

**1366** ON THE OVERTONE AND COMBINATION BANDS OF SOME CHLORINATED BENZENES. Saeki, Shinnosuke; Kajiura, Teruo. Tokyo Kogyo Shikensho Hokoku, 61: 330-47(Aug. 1966). (In Japanese).

The Raman spectra of some chlorinated benzenes in the liquid state at high temperatures were observed in the overtone regions, and their infrared spectra in carbon tetrachloride were observed between 3000 and 9000 $cm^{-1}$. From analysis of the observed Raman spectra, new information on the assignment of fundamental Raman lines was obtained. Almost all of the observed lines or bands were reasonably explained as the overtones or combination tones of the fundamental vibrations. Although the assignments for the overtones or combination tones could be made somewhat arbitrarily in general, and do not throw so much light on the assignments of the fundamental vibrations, the results support assignments of the fundamental vibrations made previously for these chlorinated benzenes. From the analysis of the overtone frequencies, the anharmonicity constants of C−H(C−D) stretching modes were determined as follows: $C_6H_4Cl_2$, 74.9; $C_6D_4Cl_2$, 33.7; $C_6H_3Cl_3$, 63.2; $C_6D_3Cl_3$, 37.3; $C_6H_2Cl_4$, 67.1; and $C_6D_2Cl_4$, 30.7. (auth)

**1367** SECONDARY KINETIC ISOTOPE EFFECTS IN THE SOLVOLYSES OF 2-(2,4-DIMETHOXYPHENYL)-1,1-$d_2$-ETHYL AND 2-(3,5-DIMETHOXYPHENYL)-1,1-$d_2$-ETHYL P-BROMOBENZENESULFONATES. Lee, C.C.; Noszko, L. (Univ. of Saskatchewan, Saskatoon). Can. J. Chem., 44: 2491-5(Nov. 1966).

The secondary $\alpha$-deuterium kinetic isotope effects in the acetolyses and formolyses of 2-(2,4-dimethoxyphenyl)ethyl and 2-(3,5-dimethoxyphenyl)ethyl p-bromobenzenesulfonates (I-OBs and II-OBs, respectively) and their corresponding 1,1-dideuterio analogs (I-OBs-1-$d_2$ and II-OBs-1-$d_2$) were determined. The observed $k_H/k_D$ values were compared with those for 2-phenylethyl and 2-p-anisylethyl p-toluenesulfonates (III-OTs and IV-OTs, respectively). In the formolyses of III-OTs, IV-OTs, and I-OBs, which proceeded either chiefly or exclusively by way of bridged ions as intermediates, the isotope effects appeared to increase slightly with increasing bridged-ion stability. For I-OBs and I-OBs-1-$d_2$, acetolyses gave smaller $k_H/k_D$ values than formolyses because of deuterium scrambling caused by ion-pair returns during the acetolysis. Acetolyses and formolyses of II-OBs and II-OBs-1-$d_2$ gave lower isotope effects than the corresponding reactions with I-OBs and I-OBs-1-$d_2$. The magnitudes of the observed isotope effects in relation to transition-state structures are discussed. (auth)

**1368** RELATION BETWEEN ULTRASONIC VELOCITY AND VISCOSITY IN AQUEOUS SOLUTIONS OF ELECTROLYTES. Prakash, Satya; Prakash, Som; Laxmi, Shobhay (Allahabad Univ. India). Bull. Chem. Soc. Japan, 39: 2114-16(Oct. 1966).

From the experimental data on the ultrasonic velocity and viscosity of thorium nitrate, lanthanum acetate, and lanthanum chloride, it has been found that the product of adiabatic compressibility and viscosity is fairly constant over the concentration range studied. From those data the relation between ultrasonic velocity and viscosity has been derived, which can explain the variation in sound velocity with the concentration. (auth)

**1369** SPECTROSCOPIC STUDIES OF DIALKYLALUMINUM ALKOXIDES AND THE TRIALKYLALUMINUM-ETHER COMPLEX. II. ASSIGNMENTS OF OBSERVED FREQUENCIES. Tarao, Ryokichi (Chisso Co., Ltd., Yokohama, Japan). Bull. Chem. Soc. Japan, 39: 2126-32(Oct. 1966).

Polarization data on the Raman lines of $Al(CH_3)_3 \cdot (CH_3)_2O$, $[Al(CH_3)_2OCH_3]_3$, $[Al(C_2H_5)_2OCH_3]_3$, and $[Al(C_2H_5)_2OC_2H_5]_2$ were obtained in the 3100 to 130 $cm^{-1}$ region. Most of the infrared absorption bands and Raman lines of these four compounds in the skeletal vibration region (720 to 130 $cm^{-1}$) have been tentatively assigned with the aid of these polarization data and on the assumption that the symmetries of these four compounds are as given in a previous paper. The Raman spectra of $Al(CH_3)_3 \cdot (CD_3)_2O$, $[Al(CH_3)_2OCD_3]_3$, and $[Al(C_2H_5)_2 \cdot OC_2D_5]_2$ have been measured in the 3100 to 130 $cm^{-1}$ region. Most of the infrared absorption bands and Raman lines of $Al(CH_3)_3 \cdot (CH_3)_2O$, $[Al(CH_3)_2OCH_3]_3$, $[Al(C_2H_5)_2OCH_3]_3$, and $[Al(C_2H_5)_2OC_2H_5]_2$ in the CH-stretching region (3100 to 2700 $cm^{-1}$) have been assigned with the aid of the spectroscopic data of the partly deuterated substances. (auth)

**1370** THE EXCHANGE REACTION OF OXYGEN ATOMS BETWEEN OXYGEN AND CARBON DIOXIDE ON METAL OXIDES OF THE FOURTH PERIOD OF THE PERIODIC SYSTEM. Kiyoura, Tadamitsu (Tokyo Metropolitan Univ.). Bull. Chem. Soc. Japan, 39: 2135-40(Oct. 1966).

The exchange reactions of oxygen atoms between $O_2$ and $CO_2$ on metal oxides were studied by the static batch method in the temperature range from 150 to 600°C. The order of the catalytic activity of the oxides in the reaction was found to be; (higher activity) $Co_3O_4 > MnO_2 > NiO > Fe_2O_3 > Cr_2O_3 > V_2O_5 > TiO_2$. A very close similarity of the change in the reactivity of these oxides was found in the exchange between oxygen and oxides. There is an approximately linear relationship between the catalyst activity of the metal oxides and the heat of the formation of these oxides. At any temperature examined, carbon dioxide exchanged their oxygen atoms with those of oxide rapidly. The rate of isotopic exchange decreased in the following order on any oxide examined: $CO_2$–Oxide > $O_2$–Oxide > $O_2$–$CO_2$ on oxide. The exchange between oxygen and carbon dioxide was observed only when the exchange between oxygen and oxide took place. According to these results, it was concluded that the exchange between oxygen and carbon dioxide takes place through the exchange between these gases and oxygen atoms of oxide, and that the rate-determining step is the exchange with oxygen. (auth)

**1371** THE FORMATION OF URANIUM TRIOXIDE BY THE OXIDATION OF URANIUM IODIDES AT LOW TEMPERATURES. Handa, Muneo (Japan Atomic Energy Research Inst., Tokyo). Bull. Chem. Soc. Japan, 39: 2315(Oct. 1966).

An apparatus and method are described for easily and accurately studying chemical reactions between gases and solids. In the apparatus, the column of a gas chromatograph is replaced with an electric furnace and traps for water vapor, $O_2$, and $I_2$. The apparatus was used to study the reaction of uranium iodides with oxygen to produce pure $UO_3$. The reactions between uranium iodides and oxygen at various temperatures are given, as are the heating curves of the iodides. (B.L.M.)

**1372** AN IMPROVED TECHNIQUE FOR THE ELECTROLYTIC GROWTH OF MOLYBDENUM(IV) OXIDE. Perloff, David S.; Wold, Aaron (Brown Univ., Providence). 10p. (CONF-660640-1). ORAU. Gmelin, AED-CONF-66-187-2.

From International Conference on Crystal Growth, Boston.

An electrolytic cell is described for use in preparation of large $MoO_4$ single crystals. Both electrode leads of the cell are connected directly to the current supply to allow replacement of the ordinary radiation shield with a ceramic shield, thereby minimizing the oxidation problem and poor electrical contacts. The cell is designed as a double cell so that $O_2$ liberated at the anode is excluded from the cathode compartment where crystal growth takes place. Following the growth period, an inert atmosphere is introduced, and the melt is lowered away from the electrode on which the crystals have grown. Slab-like crystals, 7 × 3 × 2 mm, were grown in a period of 3 days by electrolyzing a molar mixture of 1.40 $Na_2MoO_4$ : 1.00 $MoO_3$ at 675°C, 20.00 mA, and 0.75 V cell potential. (B.L.M.)

## Radiation and Nuclear Chemistry

*Refer also to abstracts 1306, 1407, 1654, 2307, and 2893.*

**1373** (AERE-R-5236) RADIATION-INITIATED CARBOXYLATION OF CYCLOHEXANE. Hills, P. R. (United Kingdom Atomic Energy Authority, Wantage (England). Research Group). Sept. 1966. 12p. (CONF-660614-7). BIS $0.50. HMSO 2s. 6d.

From 3rd International Congress on Radiation Research, Cortina, Italy.

In irradiated cyclohexane solutions, oxalyl chloride reacts by a chain mechanism to afford the acid chloride of cyclohexane carboxylic acid. No such reaction was observed in cyclohexene solutions. G-values varying from 200 to 750 are reported, which are dependent on the concentration of oxalyl chloride but apparently independent of the dose rates employed. The data obtained can be expressed in the relationship: G-value = $k[c]^a$, where c is the mole fraction of oxalyl chloride and the exponent, a, equals 0.69 ± 0.02. (auth)

**1374** (ANL-7199) COMPUTER PROGRAM FOR THE KINETIC TREATMENT OF RADIATION-INDUCED SIMULTANEOUS CHEMICAL REACTIONS. Schmidt, Klaus H. (Argonne National Lab., Ill.). Apr. 1966. Contract W-31-109-eng-38. 51p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

WR16, a program written in 3600-FORTRAN for a CDC-3600 digital computer, calculates, as a function of time, the concentrations of all the species taking part in the simultaneous first- and second-order chemical reactions occurring during and after exposure to ionizing radiation of any chemical system (for example, an aqueous solution). Homogeneous reaction kinetics are assumed for the computation. The variation of electrical conductivity and optical absorbance of the system can also be computed. As data, the program requires the chemical reaction equations with rate constants, a list of the species involved with their radiation yields, rates of spontaneous formation (if any), initial concentrations, equivalent conductances and molar absorptivities, and the dose rate duration of irradiation. A simplified version of the program, adapted for an IBM-1620 computer system, is also included. (auth)

**1375** (BLG-407) HIGH-LEVEL GAMMA DOSIMETRY USING POTASSIUM BICHROMATE. De Baere, G. C.; De Proost, M. J.; Van Elsen, T. K. (Centre d'Etude de l'Energie Nucleaire, Brussels (Belgium)). Oct. 1966. 9p. (CONF-661005-2). Dep. mn.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna, Austria.

A chemical dosimeter using $K_2Cr_2O_7$ in a dilute sulfuric acid solution is described. The decrease in optical density caused by the reduction of potassium dichromate is measured spectrophotometrically at a wavelength of 350 nm or 440 nm depending on the initial $K_2Cr_2O_7$ concentration. The yields of the radiolytic reduction in a 1N sulfuric acid solution are: for $1.5 \times 10^{-3}$ M $K_2Cr_2O_7$: 0.390 ± 0.010; for $2.5 \times 10^{-4}$ M $K_2Cr_2O_7$: 0.408 ± 0.012. These G values are independent of dose rate, but they depend on the $H^+$ concentration. The potassium dichromate dosimeter usable for absorbed doses between $10^5$ and $3 \times 10^6$ RAD permits the determination of gamma fluxes up to $5 \times 10^7$ RAD/hr. (auth)

**1376** (CALT-532-5) DIFFUSION MODEL OF THE RADIATION CHEMISTRY OF AQUEOUS SOLUTIONS. Kuppermann, Aron

(California Inst. of Tech., Pasadena. Gates and Crellin Labs. of Chemistry). Sept. 21, 1966. Contract AT(04-3)-532. 40p. (CONF-660614-6). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From 3rd International Congress on Radiation Research, Cortina, Italy.

Developments in studies on the radiolysis of aqueous solutions are summarized, and the present state of the diffusion model is analyzed. The results of computer calculations and experiment are also compared. (P.C.H.)

**1377** (ORNL-3994) CHEMISTRY DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING MAY 20, 1966. (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 172p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Research progress is reported on nuclear chemistry, isotope chemistry, radiation chemistry, organic chemistry, chemistry of aqueous systems, electrochemical kinetics and its application to corrosion, nonaqueous systems at high temperature, and chemical physics. Separate abstracts were prepared for the 8 sections. (M.C.G.)

*For abstracts of individual sections see: 1323–1326, 1378, 1424, 1864, and 2707.*

**1378** (ORNL-3994, pp 40-52) RADIATION CHEMISTRY. (Oak Ridge National Lab., Tenn.).

A program of pulse radiolysis was started in which a field emission electron accelerator will be used. The fast-recording spectrographic-spectrophotometric detection equipment was assembled and tested. A flash lamp, which provides a 3-μsec flash (5 to 95% light emission), was developed. The detection equipment allows measurement of intermediates during the flash with a time resolution of 0.1 μsec. A program of flash photolysis of aqueous solutions was initiated. The spectrum of the OH radical was determined. Hydrogen yields observed in the $^{60}Co$ gamma radiolysis of aqueous $N_2O$-saturated 2-propanol solutions are interpreted as arising from the radiolysis of $N_2O$-saturated water ($G_{H_2} = 0.34$), the H atom abstraction of hydrogen from the organic solute ($G_H = 0.61$), and a "direct effect" equal to 0.54[2-propanol]. Similar treatment of the sodium formate data yields $G_H = 0.57$ and a "direct effect" of 0.16[sodium formate]. The simultaneously measured nitrogen yields are constant, indicating that H atoms do not reduce $N_2O$ to $N_2$. Radiolysis of $N_2O$-saturated $NaNO_3$ solutions gave $k(NO_3^- + Red)/k(N_2O + Red)$ as 1.44 and the yield of reducing radicals not producing molecular hydrogen as 2.95. A program SLOPULSE was written for the CDC 1604-A computer to determine $G_{HNO_2}$ in the radiolysis of concentrated sodium nitrate solutions in 0.4M sulfuric acid containing $10^{-4}$M cerium(IV). The dependence of $G(Ce^{III})$ and $G_{HNO_2}$ on sodium nitrate concentration is very striking: an increase in $G(Ce^{III})$ with increase in sodium nitrate concentration is accompanied by an equal increase in $2G_{HNO_2}$. Two processes are required to denote the formation of earliest detectable intermediates in the radiolysis of concentrated sodium nitrate solutions in 0.4M sulfuric acid: $H_2O \rightsquigarrow H_2, H_2O_2$, H, OH and $NO_3^- \rightsquigarrow NO_2^-, O_2$. Addition of 2-propanol to concentrated sodium nitrate solutions in air-saturated 0.4M sulfuric acid containing cerium(IV) increased $G(Ce^{III})$ by $2G_{OH}$ and $G_{HNO_2}$ by $0.5G_{OH}$. This was consistent with a reaction mechanism in which $NO_2$ radicals disproportionate to yield nitrous acid and oxidation of nitrous acid by OH or $HSO_4$ is inhibited by reaction of 2-propanol with OH or $HSO_4$ to yield $CH_3COHCH_3$, which reduces cerium(IV). Gaseous carbon dioxide shows a high radiation stability because of an efficient back-reaction of products. Additives intercept the species responsible for back-reaction and permit a net production of carbon monoxide. Judging from the CO yield, hydrogen, methane, and ethylene show increasing efficiency of interception. The $CH_4$, $C_2H_4$, and possibly $H_2$ are consumed in interception but at a lower rate than that at which CO is produced. An oxygen material balance was not attained, but $CH_2OH$ and HCHO do not appear to be important products. Considerable energy transfer occurs in the radiolysis of $CH_4$–$CO_2$ mixtures, and almost as much $C_2H_6$ is produced as would be in the irradiation of $CH_4$ alone. Relative radiolytic yields for hydrogen atom formation on several adsorbents and absolute yields for three other radiolyses on adsorbents (decomposition of nitrous oxide, of isopropanol, and of formic acid) were measured. A clear dose rate effect was observed in the radiolysis of molten $LiNO_3$ to oxygen gas and nitrite ion by $^{60}Co$ gamma rays. A kinetic mechanism capable of giving a quantitative description of the experimental results was developed. (auth)

**1379** (ORNL-P-2408) CONTAINMENT OF RADIOACTIVE MATERIAL IN THE TRANSURANIUM PROCESSING PLANT. King, L. J.; Matherne, J. L. (Oak Ridge National Lab., Tenn.). [nd]. Contract W-7405-eng-26. 19p. (CONF-661001-21). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 14th Conference on Remote Systems Technology, Pittsburgh, Pa.

The Transuranium Processing Plant (TRU) at Oak Ridge National Laboratory is operated in conjunction with the High Flux Isotope Reactor (HFIR) to provide gram quantities of many of the transuranium elements and milligram quantities of some of the transcalifornium isotopes for use in research. Many of the design features of the facility are governed by the special problems associated with the containment of the high-specific-activity actinide elements. These elements are primarily alpha emitters; in addition, some undergo spontaneous fissioning. High dose rates of penetrating radiation, including fast neutrons from spontaneous fission, necessitate thick shielding (54 in. of high-density concrete) and require all maintenance to be done remotely. Special containment features of this plant are described. Facilities for handling radioactive materials consist of nine heavily shielded cells equipped with master-slave manipulators and windows, and eight laboratories. Within each cell, process equipment is enclosed in a cell cubicle. Four of the cell cubicles contain chemical processing equipment; three are used for remote fabrication of recycle targets for further irradiation in the HFIR; and two are used for remote analytical chemistry work. Behind and below each cubicle and shielded from it by a concrete wall is a tank pit for housing waste collection equipment and process and storage tanks. The usual containment practice of providing multiple, enclosed ventilation systems is used. Process equipment is enclosed in sealed cubicles within the primary cells, which are in turn enclosed by the building shell. Each enclosure is separately ventilated with differential pressures, maintained automatically, so that each enclosure is at a lower pressure than its immediate envelope. Portals between building areas and from the building are equipped with air locks. The building shell is maintained continuously at a vacuum of 0.3-in. $H_2O$ gage to ensure absolute containment of all activity within the building. This compares with the standard practice at ORNL of bringing a building vacuum to 0.3-in. $H_2O$ gage within 20 sec in case of emergency, while normally maintaining the facility at atmospheric pressure. The glove-box ventilation system, the cell cubicle ventilation system, and the processing-cell ventilation system are designed so that all glove boxes, cells, and cubicles are exhausted to common headers (one for each system) that have automatic instrumentation to control pressures. The flow rate of purge air is controlled by throttling the inlet. Thus, the glove boxes, cubicles, and cells "float" on the respective headers, which provide extra ventilation capacity to prevent pressure buildup. The headers are capable of exhausting at least one-tenth volume per minute from the attached enclosed processing box, cell, or cubicle. (auth)

**1380** (RRL-2310-188) QUARTERLY REPORT [ON RADIATION RESEARCH], JULY 1–SEPTEMBER 30, 1966. Fundamental Research No. 6041. (Radiation Research Labs., Mellon Inst., Pittsburgh, Pa.). Oct. 10, 1966. Contract AT(30-1)-2310. 19p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Developments are reported for studies on: spectra and kinetics of tetravalent iron in pulse-irradiated ferric perchlorate solutions; argon-sensitized radiolysis of ethylene in liquid phase; radiation chemistry of liquid methane; theory of structure of the $PF_4$ radical; electronic structures of NCN and CNC; hydroxyl radical oxidation of ferrous ion by pulse radiolysis of nitromethane in aqueous solutions; spectra of oxygen-containing transient species; radioinduced hydroxylation of aromatic compounds in aqueous solutions; gas phase reactions of $O^-$; Hg ($^1P_1$)-photosensitized decomposition of cyclobutane; addition of hydrogen atoms to ethylene in liquid hydrocarbons; electron capture yields in radiolysis of hydrocarbon solutions; ESR studies in irradiated $SF_6$; and ESR observations on radicals in polar liquids. (P.C.H.)

**1381** (TID-23407) THE RADIATION INDUCED POLYMERIZATION AND COPOLYMERIZATION OF UNUSUAL MONOMERS. Technical Progress Report, March 1–August 15, 1964. Stannett, V. T. (Research Triangle Inst., Durham, N. C. Camille Dreyfus Lab.). Aug. 26, 1964. Contract AT(40-1)-2513. 27p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The nitriles and cyclopropane derivatives all gave very low yields of polymer when irradiated with up to 100 MRADS under a wide range of conditions. Metaldehyde and benzaldehyde gave no polymer or copolymer with styrene under various radiation treatments. Formaldehyde and styrene when irradiated together as a paste at –78°C gave excellent yields of a 90:10 formaldehyde-styrene random copolymer with a thermal stability greatly superior to unmodified polyoxymethylene. Sulfur dioxide copolymers were produced at room temperature and below with extremely high G values. Solvents were found for the isoprene and chloroprene copolymers, which open the way to successful utilization of these potentially interesting polymers. The sulfur analog of trioxane, trithiane, was successfully polymerized in the crystalline state by radiation followed by heating to give 3-dimensionally oriented crystalline polymer. This solid-state polymerization, which leads to an industrially interesting polymer, is under investigation. (auth)

**1382** (ORNL-tr-1246) METHOD FOR PRODUCING A PHOSPHORUS ISOTOPE. Godar, S. Translated for Oak Ridge National Lab., Tenn., from Belgian Patent 633,780. 3p. Dep. mn. JCL $1.10 fs, $0.80 mf.

A method for producing $^{33}P_{15}$ by neutron irradiation of $^{33}S_{16}$, in which the reaction $^{33}S(n,p)^{33}P$ takes place, is described. The reaction is carried out with an accelerator, which produces protons of about 2.7 MeV that are used in the $^{7}Li(p,n)^{7}Be$ reaction, the neutrons of which react with the natural sulfur. (M.C.G.)

**1383** POLAROGRAPHIC STUDY OF THE EFFECTS OF γ-RADIATION ON CYTOSINE. Pleticha-Lansky, R.; Weiss, J. J. (Univ. of Newcastle upon Tyne, Eng.). Anal. Biochem., 16: 510-22(Sept. 1966).

Some aspects of the saturation of the 4.5 double bond during the γ-irradiation of cytosine are described. Visible effects of the irradiation of $10^{-2}$M aqueous solutions with ~$10^6$ Rad $^{60}$Co gamma rays were a lemon-yellow coloration and a green fluorescence ascribed to the formation of 4,4′-diisobarbituric acid when irradiation was carried out in air. Further radiolytic products were found and identified as isodialuric and dialuric acid, and the very easy oxidation of the latter was found to lead to the formation of alloxan and subsequently to the system where dialuric acid and alloxan are in equilibrium with alloxantin. Radiolytic products were determined by polarographic methods, and investigation of the initially irradiated solution showed a decrease in the limiting current of the single characteristic reduction wave at $E_{\frac{1}{2}}$ -1.72V. (B.L.M.)

**1384** RADIATION-INDUCED ADDITION REACTION OF THIOLS TO CHLOROFLUOROOLEFINS. Inukai, Kan; Ueda, Teruo; Muramatsu, Hiroshige (Government Industrial Research Inst., Nagoya, Japan). Bull. Chem. Soc. Japan, 39: 2191-4(Oct. 1966).

The addition of thiols to chlorofluoroethylenes was carried out under γ-ray irradiation; chlorofluoroethyl alkyl sulfides were thus obtained. Chlorofluoroethyl alkyl sulfoxides and sulfones were prepared by the oxidation of the sulfides. The dehydrohalogenation of chlorofluoroethyl alkyl sulfides yielded chlorofluorovinyl alkyl sulfides, whose structure indicated that the thiyl radical attacked the difluoromethylene side of the asymmetrical dichlorodifluoroethylene. Chlorofluorovinyl sulfoxides and sulfones were also synthesized from the sulfides by oxidation with hydrogen peroxide. (auth)

**1385** PULSE RADIOLYTIC INVESTIGATIONS OF THE ELECTROLYTIC DISSOCIATION OF ALIPHATIC ALCOHOL RADICALS. Asmus, K.-D.; Henglein, A.; Wigger, A.; Beck, G. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Ber. Bunsenges. Physik. Chem., 70: 756-8(Sept. 1966). (In German).

Alcohol radicals are known to dissociate in alkaline solutions according to the following equilibrium. $R_1R_2\dot{C}OH \rightleftharpoons R_1R_2\dot{C}O^- + H^+$. The optical absorption spectra of the acid and basic forms of several radicals and the dissociation constants of the corresponding equilibria were determined. The $p_K$-value of an alcohol radical becomes higher the more negative Taft's σ*-value for the inductive effect of the $HR_1R_2C$- group becomes. Hydroxyl radicals from the radiolysis of water react with dissolved alcohols to form the undissociated form; hydrated electrons react with dissolved aldehydes (or ketones) to yield the anionic form. The equilibrium is reached in short times from both sides. This fact is explained by participation of $OH^-$ ions and water molecules according to $R_1R_2\dot{C}OH + OH^- \leftrightarrow R_1R_2\dot{C}O^- + H_2O$. (auth)

**1386** EFFECT OF REACTION CONDITIONS ON THE FORMATION OF POLYSULFONE OF OLEFINS WITH SULFUR DIOXIDE INDUCED BY γ RADIATION, AND THE SEVERAL PROPERTIES OF THE POLYSULFONES. Urano, Yokichi; Hosaka, Yoshinobu. Tokyo Kogyo Shikensho Hokoku, 61: 352-7(Aug. 1966). (In Japanese).

Polysulfone reaction of lower olefins (ethylene, propylene, butene-1 and butene-2) with sulfur dioxide initiated by γ-radiation was carried out using a stainless steel reactor with the following experimental conditions: temperature, −78 to 100°C; mole fraction of olefin, 0.2 to 0.9; reaction duration, 0.25 to 24 hr; and dose rate of $3 \times 10^4$ to $4 \times 10^4$ RAD/hr. The polysulfones thus obtained were white powder, which could be molded with a hot press. The maximum yields were obtained at around 0°C and 0.5 mole fraction of olefins for all combinations. Some physical properties and stabilities toward heated and alkaline solutions of the polysulfones are tabulated. (auth)

**1387** γ-RADIATION-INDUCED HYDROGEN EXCHANGE REACTION IN LIQUID CYCLOHEXANE–HYDROGEN CHLORIDE SOLUTIONS. Fletcher, J. W.; Freeman, G. R. (Univ. of Alberta, Edmonton). Can. J. Chem., 44: 2645-9(Nov. 15, 1966).

The overall exchange reactions: $HCl + c\text{-}C_6D_{12} \rightarrow DCl + c\text{-}C_6D_{11}H$ and $DCl + c\text{-}C_6H_{12} \rightarrow HCl + c\text{-}C_6H_{11}D$ were initiated by radiolysis and measured by a nuclear magnetic resonance spectroscopic method. The reactions occur by a chain mechanism, with a chain length of ~$10^4$ in a 1M solution of hydrogen chloride in cyclohexane. The mechanism is complex. The exchange reaction can also be initiated by the photolysis of chlorine or of hydrogen chloride. A chain exchange reaction does not occur between $c\text{-}C_6H_{12}$ and DI, $D_2S$, or $ND_3$. These results are consistent with the suggestion that the exchange reaction in the cyclohexane–hydrogen chloride system occurs by a free radical chain mechanism. This type of exchange reaction can cause difficulties in isotopic tracer studies. (auth)

**1388** RADIOCHEMICAL SYNTHESIS OF THE DYESTUFFS. Vasilescu, I. J. Rev. Chim. (Bucharest), 17: 411-13(July 1966). (In Rumanian).

Reactions initiated by ionizing radiations were used for the radiosynthesis of natural dyes and pigments. The leuco base of fluorescein exposed to x radiation or to α particles in the absence of air was oxidized to the colored dye. In some cases, the dye formed by radiation was subsequently destroyed by extended exposure. Methylene blue was formed by a redox reaction mechanism, initiated by radiation-generated free radicals. The leucocyanide of malachite green, irradiated in a dilute alcoholic solution in the absence of oxygen also formed the dye; this reaction was initiated by the peroxide radicals formed by the radiolysis of the solvent, resulting in the breakup of the C–CN bond. Although these reactions have not yet found a practical application, they are considered important because they demonstrate the possibility of the radiosynthesis of complex organic molecules. Improvement of the yield may result in industrial application. Up to now, no azo dyes were synthetized but it was noted that the mechanism of radiosynthesis is very similar to that of photosynthesis. (Review article). (TTT)

**1389** RADIOLUMINESCENCE IN A MIXTURE OF BENZENE AND METHYL ALCOHOL. Spurny, Z.; Spurny, F. (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez. Inst. of Dosimetry and Application of Ionizing Radiation, Prague. Inst. of Technology, Prague). Collect. Czech. Chem. Commun., 31: 3702-9(Sept. 1966).

The intensity of the radioluminescence of 2,5-diphenyl-1,3-oxazole (PPO) and 2-phenyl-5-(4-biphenylyl)-1,3,4-oxadiazole (PBD) solutions in mixtures of benzene and methyl alcohol was followed in relation to the ratio of both components of the mixture and the concentration of the scintillator. In the concentration range from 0 to 80 vol % of methyl alcohol it was observed that only excitation energy transfer from benzene to the scintillator takes place. Methyl alcohol lowered the intensity of radioluminescence to a greater extent than corresponds to its electron fraction. Its quenching effects are exhausted at about 30 vol % and appear predominantly static; only in the range of 0 to 20 vol % do they appear dynamic. (auth)

**1390** THERMAL DECOMPOSITION OF IRRADIATED ORTHORHOMBIC AMMONIUM PERCHLORATE. Herley, P. J. (Picatinny Arsenal, Dover, N. J.); Levy, P. W. Nature, 211: 1287-8(Sept. 17, 1966).

Transparent crystals of ammonium perchlorate were prepared, irradiated with $9.8 \times 10^6$ rad of $^{60}$Co gamma radiation, and subjected to thermal decomposition. Rate constants and activation energies were determined for the induction, acceleratory, and decay periods. The effects of gamma irradiation appear to be a shortening of the induction period and an increase in the rate of three-dimensional growth during the acceleratory period, until a coherent interface is built up on the material between the mosaic blocks. The increase in the rate constant during the acceleratory period might be attributed to an increase in the number of decomposition nuclei present. (J.G.B.)

**1391** AN INVESTIGATION OF X-IRRADIATED KCl : H AND NaCl : H. Hayes, W.; Hodby, J. W. (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A., 294: 359-75(Oct. 4, 1966).

The EPR spectrum of a new hydrogen atom center called the $U_3$ center was observed after x irradiation of KCl : H crystals at low temperatures and was assigned to hydrogen atoms in chlorine sites. The center bleaches thermally at 145°K with an activation energy of 0.43 ± 0.03 eV. Optical bleaching experiments indicate that the center has a weak absorption band peaking at 2.9 eV. The center cannot be produced by ultraviolet irradiation. A production mechanism involving $V_k$ centers is proposed and is discussed in detail. The $U_3$ center was also observed in NaCl : H. (auth)

**1392** HYDROGEN PEROXIDE DETERMINATION IN IRRADIATED HEAVY WATER SATURATED WITH CARBON DIOXIDE. Mrkous, Pavel; Horsky, Jifi. Jad. Energ., 12: 361-7(Oct. 1966). (In Czech).

The determination of $D_2O_2$ in $D_2O$ contaminated with corrosion products of aluminum alloys and steel, and saturated with carbon

dioxide at different pressures is described. The results obtained indicated the stabilization of $D_2O_2$ by carbon dioxide dissolved in $D_2O$, and the decomposition of $D_2O_2$ by iron ions. On the aluminum alloy surface contact decomposition probably occurs. The time dependence of $D_2O_2$ concentration on the interval of exposure in the WWR-S reactor is reported. (auth)

**1393** MICROANALYTICAL INFORMATION OF THE INITIATION REACTION IN THE γ-RADIATION-INDUCED POLYMERIZATION OF ETHYLENE. Mitsui, Hiroshi; Machi, Sueo; Hagiwara, Miyuki; Kagiya, Tsutomu (Japan Atomic Energy Research Inst., Gumma). J. Polym. Sci. Pt. B, 4: 881-2(Nov. 1966).

The gaseous products from the γ-induced polymerization of ethylene at temperatures of 30 to 45°C and at a pressure of 400 kg/cm² were identified as mainly hydrogen and acetylene by chromatographic methods. No gaseous hydrocarbons higher than $C_3$ were identified by gas chromatography. The number of moles of polymer chain was found to be almost equal to the moles of acetylene formed, and the amounts of both hydrogen and acetylene increased linearly with reaction time. (B.L.M.)

**1394** CHARGE RECOMBINATION IN THE RADIOLYSIS OF LIQUID AND GLASSY HYDROCARBONS. Williams, Ffrancon; Hayashi, Koichiro (Kyoto Univ.). Nature, 212: 281-2(Oct. 15, 1966).

In an attempt to explain the radioinduced conductivity of hydrocarbon polymers, the mechanism of diffusive motion was used to predict the absolute rate of recombination in simple hydrocarbon glasses. The mathematical calculation of the recombination time is compared with some recently published experimental results with agreement within a power of 10 or better. (B.L.M.)

**1395** OXYGEN AS A PRIMARY SPECIES IN RADIOLYSIS OF WATER. Daniels, Malcolm; Wigg, Eric (Oregon State Univ., Corvallis). Science, 153: 1533-4(Sept. 23, 1966).

Recent results are summarized of γ radiolysis of dilute nitrate solutions at neutral pH in the presence of oxygen and hydrogen as radical scavengers. Complete analysis of the system leads to values of the primary yields showing a net deficit of oxidized products of ~0.4. Analysis of results already available for the oxygen yield shows that oxygen originated from the radiolysis of water with a g value of ~0.1 (g values are derived values for yields of primary species for 100 electron volts). This finding gives material balance and provides evidence of oxygen being a product of water radiolysis. (auth)

**1396** CHANGE IN CATALYTIC ACTIVITY OF ALUMINA IN DEHYDRATION REACTIONS OF n-DECYL ALCOHOL AND IN ISOMERIZATION OF α DECENE BY MEANS OF IRRADIATION. Pirogova, G. N.; Spitsyn, Vikt. I. (Inst. of Physical Chemistry, Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Khim., No. 10, 1691-4(1966). (In Russian).

The effects of fast electrons, uv rays, mixed neutrons, and radioactive $^{90}Y$ on the catalytic dehydration of 1-decanol over $Al_2O_3$ and isomerization of produced α-decene were investigated. Irradiation of alcohol vapors by fast electrons does not affect its catalytic conversion. Preliminary treatment of aluminum oxide by uv rays also does not influence $Al_2O_3$ catalytic activity. Uv irradiation during alcohol vapor reactions with the catalyst inhibited olefin yield, but treatment of $Al_2O_3$ with mixed slow and fast neutrons ($10^{13}n/cm^2 \cdot sec$) in a reactor does not increase catalytic activity. Injection of $^{90}Y$ (5 m Cu/g) reduced the degree of alcohol conversion. A partial reduction of the initial activity is achieved during radioactive decay. (tr-auth)

**1397** PHOTOCHEMICAL REACTIONS IN ANALYTICAL CHEMISTRY. I. THE USE OF PHOTOCHEMICAL REDUCTION OF URANIUM(VI) TO URANIUM(IV) FOR ITS TITRIMETRIC DETERMINATION IN SULFURIC ACID SOLUTIONS. Nemodruk, A. A.; Bezrogova, E. V. Zh. Anal. Khim., 21: 1210-16(1966). (In Russian).

A study was made of the photochemical reduction of U(VI) to U(IV) using ethanol as a reducing agent depending on the concentrations of sulfuric acid and ethanol, time of irradiation, temperature of irradiated solution, nature of the irradiation source, and distance from solution surface to irradiation source. Conditions were found which ensured the quantitative reduction of U(VI) to U(IV). The interference of other elements was discussed. Photochemical reduction of U(VI) followed by the titration of U(IV) with ammonium vanadate using N-phenylanthranilic acid as an indicator permits uranium determination in solutions at its concentration of 0.02 mg/ml and more. The experimental error is not more than 0.5%. One determination takes about 15 min. (auth)

**1398** ESR STUDY OF THE FREE RADICALS PRODUCED BY THE γ IRRADIATION OF PYRIDINE. David, C. (Univ. Libre, Brussels); Geuskens, G.; Verhasselt, A.; Jung, P.; Oth, J. F. M. Mol. Phys., 11: 257-63(1966).

Pyridine and pyridine-$d_5$ were irradiated with gamma rays at 77°K and the ESR spectra were studied as a function of temperature up to the melting point of the compounds. The spectra show that at least two radicals are present at 77°K. The spectrum observed at that temperature with pyridine consists of a triplet (splitting 30 G) superimposed on a more complex signal. The same triplet is observed with pyridine-$d_5$ and was assigned to a radical cation formed by abstraction of an electron from the nitrogen lone pair. As the temperature is raised, the total intensity of the ESR signal decreases and the triplet disappears leaving, in the case of pyridine, a spectrum consisting of eight equidistant lines (splitting 12 G). This spectrum has been assigned to a radical formed by the capture of a hydrogen atom by the nitrogen. It was concluded that the smaller radiochemical stability of pyridine as compared with that of benzene has to be related to the presence of the lone pair electrons of nitrogen. (auth)

**1399** RADIATION-INDUCED OXIDATION OF ETHANE IN AQUEOUS SOLUTION. Ahmad, M.; Clay, P. G. (Imperial Coll. of Science and Tech., London). J. Chem. Soc., B, No. 9, 845-9(1966).

Aqueous solutions of ethane–oxygen mixtures were irradiated with γ rays, at room temperature; the major products were acetaldehyde ethanol, and ethyl hydroperoxide, the last being formed at pH 5.5 and 10 but not at pH 1.2. Photolysis of hydrogen peroxide solutions containing dissolved ethane and oxygen resulted in the formation of ethanol and acetaldehyde only. The results were interpreted in terms of reactions of ethyl peroxy radicals. (auth)

**1400** METHOD FOR PRODUCING DIMETHYLKETENE COPOLYMERS BY IONIZING RADIATION. Tashiro, Shigeki (to Japanese Association for Radiation Research on Polymers). Japanese Patent 1965-22076. Sept. 30, 1965. Filed Sept. 6, 1962.

A method is proposed for the production of dimethylketene copolymers with aldehydes, ketones, cyclic ethers, esters of organic acids, or ethylenimine by irradiation. Dimethylketene is known to copolymerize with aldehydes, ketones, or esters of organic acids by the catalytic action of some metallic compounds, but no reports have yet been made on the copolymerization of dimethylketene with cyclic ethers or ethylenimine. By the method, aldehydes, ketones, cyclic ethers, esters of organic acids, or ethylenimine can be copolymerized with dimethylketene in the liquid or solid state below its boiling point, 34°C, by irradiation in the presence or absence of an inert solvent. (NSA of Japan)

**1401** METHOD FOR PRODUCING DIMETHYLKETENE POLYMER BY IONIZING RADIATION. Tashiro, Shigeki (to Japanese Association for Radiation Research on Polymers). Japanese Patent 1965-22075. Sept. 30, 1965. Filed Sept. 6, 1962.

A method is proposed for producing dimethylketene polymer by radioinduced polymerization of the monomer in the liquid or solid state below its boiling point, 34°C, without use of metallic compounds. The irradiation can be carried out either in the presence or absence of an inert solvent. (NSA of Japan)

**1402** METHOD FOR PRODUCING ALICYCLIC LACTONES. Tsuda, Teizo (to Toyo Rayon Co., Ltd.). Japanese Patent 1965-22177. Oct. 1, 1965. Filed July 2, 1963.

A method is proposed for producing alicyclic lactones by oxidation of alicyclic ketones. The ketones are oxidized to lactones by irradiating them with ionizing radiation at 0 to 160°C in the presence of aromatic aldehydes while molecular oxygen is blown into them. (NSA of Japan)

**1403** METHOD FOR PRODUCING POLYVINYL ALCOHOL-BONDED WHETSTONE. Horie, Tomohiro. Japanese Patent 1965-21395. Sept. 22, 1965. Filed Nov. 12, 1962.

A method is proposed for producing a highly effective resin-bonded whetstone with improved mechanical properties. A homogeneous mixture of solid polyvinyl alcohol and wheat grains, having a water content of 20%, is irradiated with either ultrasonic waves or ionizing radiation in the presence of heat in the mold under pressure. The product is insoluble or only slightly soluble in water. (NSA of Japan)

**1404** METHOD FOR TREATMENT OF POLYMERS. Shinohara, Yasuo; Yamaguchi, Kenji (to Toyo Rayon Co., Ltd.). Japanese Patent 1965-23342. Oct. 14, 1965. Filed Apr. 9, 1963.

A method is proposed for the crosslinking of polymers with only a few tenths of the radiation dose required in the simple radiation-crosslinking process. The polymers are irradiated with ionizing radiation in the presence of or in contact with acetylene, or the polymers are irradiated under any arbitrary atmosphere and then brought into contact with acetylene. (NSA of Japan)

**1405** METHOD FOR PRODUCING FOAMED BODIES OF SYNTHETIC RESINS. Kanai, Masanori (to Sekisui Chemical

Co., Ltd.). Japanese Patent 1965-24388. Oct. 25, 1965. Filed Feb. 15, 1963.

A method for producing foamed bodies of synthetic resins with excellent thermal stability and high mechanical strength includes the following steps: (1) mixing of one or more of the monomers selected from the group consisting of acrylamide, methacrylamide, acrylic acid, and methacrylic acid, a thermally decomposed foaming-agent, a mineral acid of high acidity, and any monomer, if necessary, copolymerizable with the monomers mentioned; (2) polymerization of the mixture to give the thermoplastic body containing the foaming agent homogeneously; and (3) heating the plastic body to a temperature above the softening point of the plastic in order to give simultaneously the foaming and the crosslinking reaction between the polymer molecules. The various polymerization methods such as polymerization with catalysts or initiators, thermal polymerization, radioinduced polymerization, photopolymerization with ultraviolet or visible lights, and ultrasonic polymerization are applicable to the method; however the radioinduced polymerization or the catalytic polymerization followed by irradiation gives the best results. (NSA of Japan)

**1406** METHOD FOR POLYMERIZING TETRAFLUOROETHYLENE CONTINUOUSLY IN GAS PHASE. Yamada, Akira (to Daikin Kogyo Co., Ltd.). Japanese Patent 1965-22078. Sept. 30, 1965. Filed Nov. 13, 1962.

The circulating system employs a cyclone type polymerization reaction apparatus in which the tetrafluoroethylene monomer liquefied above 50% or supercooled is irradiated with electrons or other radiation beams at radiation doses below $1.0 \times 10^4$R. The polymerization temperature is controlled by its latent heat of vaporization, and the heating coefficient of the apparatus is increased by means of the cyclone flow of circulated tetrafluoroethylene monomer, thereby accelerating the reaction rate. The resulting polymer is taken out of the system continuously to prevent the excessive irradiation. At the same time the unreacted monomer is removed and passed through a cooling device, if necessary, to remove the reaction heat. New monomer is added to the cooled monomer, liquefied above 50% or supercooled, and the mixture is sent into the reaction apparatus. Damage to the physical properties of the produced tetrafluoroethylene due to excessive radiation is avoided by this procedure. (NSA of Japan)

## Radiochemistry

*Refer also to abstract 1625.*

**1407** CHEMICAL STATE OF $^{32}P$ ATOMS RESULTING THROUGH (n,p) REACTION FROM ELEMENTARY SULFUR. I. THE BEHAVIOUR OF $^{32}P$ IN THE PRESENCE OF $PCl_5$. Bebesel, P. I.; Turcanu, C. N. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Chim., 11: 891-5(July 1966).

The chemical state of $^{32}P$ atoms resulting through (n,p) reactions in elementary sulfur was studied. The formation of a phosphorus compound labeled with $^{32}P$ as a result of the reaction between atoms of radioactive phosphorus from irradiated sulfur targets in the reactor and phosphorus pentachloride, was put into evidence. The formation of this marked compound shows the existence of $^{32}P$ atoms in a reactive state. A new method of obtaining phosphorus compounds labeled with $^{32}P$ of high specific activity, in an entirely new way, was found. (auth)

**1408** POSITRONIUM CHEMISTRY AND ANGULAR DISTRIBUTION OF ANNIHILATED $\gamma$ QUANTA. Gol'danskii, V. I.; Egiazarov, B. G.; Shantarovich, V. P. pp 48-58 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds). Moscow, Atomizdat, 1966. (In Russian).

The chemistry of the positron is discussed from the point of view of conversion reactions and chemical reactions. (Chem. reaction: $Ps + Ox \rightarrow Red. + e^+$ and the positron will be annihilated in $5 \times 10^{-10}$ sec.) To test experimentally some of the ideas discussed, aqueous mixtures of many substances were exposed to a $^{64}Cu$ source and the activity of the positron in relation to various other ions was studied. The results are interpreted in terms of conversion and oxidation reactions and of combinations of these two. The experimental results are compared with the results obtained by Tramp. (G.O.Y.)

**1409** DETERMINATION OF $^{131}I$ SPECIFIC ACTIVITY BY PROTEIN IODINATION. Glover, J. S.; Shepherd, B. P. (Radiochemical Center, Amersham, Eng.). Nature, 212: 285-6(Oct. 15, 1966).

The process of protein iodination was applied to the determination of specific activity of $^{131}I$ produced by irradiation of Te. Insulin was used as the protein material for the studies, and the accuracy of the method is reported to be within a 35% limit of error. (B.L.M.)

**1410** CONTRIBUTION TO THE ERROR THEORY IN LOW ACTIVITY MEASUREMENTS. Bartosek, Jiri; Jelinek, Vit (Inst. of Geophysics, Brno). Jad. Energ., 12: 386-8(Oct. 1966). (In Czech).

A formula was obtained for calculating the relative standard error in low-activity measurements. The effect of optimum total measuring time on the specimen and the background measurements was evaluated. Optimum measuring time was found for a series of specimens. (R.V.J.)

**1411** PROGRESS OF RADIOCHEMICAL RESEARCH IN CZECHOSLOVAKIA. Chutny, Bohumir (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez); Plander, Emil. Jad. Energ., 12: 371-8(Oct. 1966). (In Czech).

A brief review is given of radiochemical research in Czechoslovakia and technological applications of radioisotopes in its industry. Extensive bibliographies are included. (R.V.J.)

**1412** ACTIVITY LOSS IN HANDLING AQUEOUS $^{131}I$ SOLUTIONS. Moldenhawer, F.; Uhlig, B. (Staatliche Zentrale fuer Strahlenschutz, Berlin). Isotopenpraxis, 2: 333-8(Aug. 1966). (In German).

In handling very weak or strong acid solutions of $Na^{131}I$ high activity losses may occur at room temperature and especially in evaporation at elevated temperatures. The amount of escaping $^{131}I$ is dependent on both experimental conditions and the acid anion. Neutral salts, such as NaCl, NaBr, or $Na_2SO_4$, also lead to an increase of the $^{131}I$ volatility. The carrier salt NaI (up to about $10^{-3}$M) decreases the volatility very much under conditions and may be equal to $NaHCO_3$ or NaOH in this respect. A specific effect of reducing or oxidizing agents was not observed. The reducing and oxidizing agents tested increased the volatility rate more or less, with the exception of $Na_2S_2O_3$, which was shown to be the most efficient addition to inhibit activity losses. No losses of $^{131}I$ occurred in long-termed open standing of $Na^{131}I$ solutions produced by diluting $^{131}I^-$ (for medical purposes) by water of various purities. When the solution is evaporated to dryness, low volatility is possible. The concentration of such solutions at elevated temperatures is connected with activity losses the amounts of which are dependent on the purity of the water used in dilution. The experiments showed that no volatility of $^{131}I$ may be expected for the main conditions of $^{131}I$ application in medicine and that both the initial aqueous solution and the diluted solutions produced from it by adding distilled or bidistilled water may be excluded as the source of contamination of the room air. (auth)

**1413** A STUDY OF THE RECOIL BEHAVIOUR OF $^{56}Mn$ ATOMS IN DILUTE SOLUTIONS OF MANGANESE CARBONYL COMPOUNDS. Zahn, Ursel (Technische Hochschule, Munich). 23p. (CONF-660431-8). ORAU.

From Symposium on Hot Atom Chemistry, Lafayette, Ind.

The concentration and temperature dependence of $^{56}Mn$ retention after neutron bombardment of dilute solutions of cyclopentadienyl manganese tricarbonyl, $C_5H_5Mn(CO)_3$, and dimanganese decacarbonyl, $Mn_2(CO)_{10}$, in various organic solvents were studied. The concentration- and temperature-independent part of the parent compound retention is very low and primary in its nature, due to failure of bond rupture after the $(n,\gamma)$ reaction. Secondary, thermal diffusive reactions, start to contribute to retention in solutions of higher concentrations of $C_5H_5Mn(CO)_3$, and can be further enhanced by increasing the applied $\gamma$ dose. A contribution of hot exchange reactions could be excluded by a scavenger technique. The magnitude of the primary $^{56}Mn$ retention changes in solutions of $C_5H_5Mn(CO)_3$ with the character of the surrounding solvent molecules; and appears to depend on the differing ability of the solvent molecules to carry away a part of the excitation energy. In solutions of $Mn_2(CO)_{10}$ the magnitude of the $^{56}Mn$ retention is determined by the rupture of the weak Mn – Mn bond. Frozen solid solutions show high retention similar to crystalline $C_5H_5Mn(CO)_3$. (auth)

## Separation Processes

*Refer also to abstracts 1251, 1541, and 2864.*

**1414** (BNWL-301) APPLICATION OF SAFEGUARDS TO NUCLEAR FUEL PROCESSING PLANTS. Granquist, D. P.; Schneider, R. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 1966. Contract AT(45-1)-1830. 52p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Safeguard procedures developed for chemical processing plants operating with a Purex-type flowsheet are discussed. It was assumed that safeguards start with receipt of irradiated fuel at the separations plant and end when the material is shipped from the site. The study of instruments and hardware necessary to provide adequate safeguards was purposely limited to available equipment and did not include the laboratory development of spe-

cial apparatus. It is believed that such apparatus could be developed with further work. The topics covered include: philosophy of control; safeguards problems in typical plant operation; inspection procedures; measurement and accounting procedures; and effectiveness of material balance control. (P.C.H.)

**1415** (BNWL-301(App.)) A MODEL SAFEGUARDS LABORATORY. AN APPENDIX TO BNWL-301: APPLICATION OF SAFEGUARDS TO NUCLEAR FUEL PROCESSING PLANTS. Granquist, D. P.; Schneider, R. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 1966. Contract AT(45-1)-1830. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

In order to present a realistic appraisal that includes specific details on the number of personnel, equipment, and tasks to be performed by an inspection team, a particular set of conditions to exemplify the problems involved was selected. A safeguards laboratory that is assumed to be an integral (yet independent) part of a separations plant processing 100 to 200 tons of uranium per year is portrayed. (P.C.H.)

**1416** (INP-490/C) INFLUENCE OF THE INTERFACIAL TENSION ON THE PARTITION COEFFICIENT OF URANIUM IN THE SYSTEM: DILUENT + TETRABUTYLPYROPHOSPHATE/1 M $HNO_3$. Mikulski, J.; Szeglowski, Z. (Institute of Nuclear Physics, Krakow (Poland)). July 1966. 8p. Dep.

Interfacial tension measurements were made for the extraction systems diluent + TBPP/1 M $HNO_3$ containing $4.9 \times 10^{-4}$ M of uranyl nitrate enriched with $^{235}U$. It was established that the partition coefficient of uranium attains maximum at the interfacial tension of ~20 dynes/cm. (auth)

**1417** (IS-T-116) THE SEPARATION OF TIN FROM OTHER ELEMENTS BY REVERSED-PHASE CHROMATOGRAPHY. Latwesen, Gary Lee. (Ames Lab., Iowa). Aug. 1966. Contract W-7405-eng-82. 54p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Thesis.

Tin(IV) is quantitatively separated from molybdenum(VI), antimony(V), bismuth, cadmium, copper, mercury, lead, or zinc by reversed-phase chromatography using Teflon-6 as the solid support. For the separation of tin(IV) and molybdenum(VI) the stationary phase is methyl isobutyl ketone(MIBK). Molybdenum(VI) is eluted with 1M hydrochloric acid–3M sulfuric acid, and tin(IV) is stripped from the column with equilibrated MIBK. Isopropyl ether equilibrated with 8M hydrochloric acid is used as the stationary phase for the separation of tin(IV) and antimony(V). Tin(IV) is eluted with 8M hydrochloric acid, and the antimony(V) is stripped from the column with isopropyl ether. MIBK equilibrated with 8M hydrochloric acid is used as the stationary phase for the separation of tin(IV) from bismuth, cadmium, copper, mercury, lead, or zinc. Tin(IV) is held on the column while the other metal is eluted with 8M hydrochloric acid. The tin is then stripped from the column with MIBK. In all separations 0.4 mmole amounts of each metal ion are used. Small amounts of antimony(V) are also separated from 100 and 1000 times as much tin(IV). Distribution ratios are given for the extraction of all the metal ions studied from various concentrations of hydrochloric acid into MIBK. The effects of sulfuric and hydrofluoric acids on the extractabilities of tin(IV) and molybdenum(VI) from hydrochloric acid into MIBK are also considered. (auth)

**1418** (ISO-SA-6) APPLIED DEVELOPMENT OF THE PULSE COLUMN. Duckworth, J. P. (Isochem Inc., Richland, Wash.). Feb. 25, 1966. Contract AT(45-1)-1851. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The design and development of a pulse column for use with the Purex Process for the separation of U, Pu, and Np from fission products are described. Regarding the design and operation of a pulse column, there were many variables to be considered. These included such variables as materials of construction, types of plates, plate spacings and hole sizes which relate to the cartridge of a pulse column, chemical variables, physical variables, and others such as volume velocity, flow ratios of the aqueous and organic liquids, and energy input measured by the amplitude times the frequency of the pulser. (P.C.H.)

**1419** (MLM-1352) STABLE GASEOUS ISOTOPE SEPARATION AND PURIFICATION, JANUARY–MARCH 1966. Haubach, W. J.; Grove, G. R. (Mound Lab., Miamisburg, Ohio). Mar. 31, 1966. Contract AT(33-1)-Gen-53. 51p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Developments in studies on the separation and purification of stable rare gas isotopes by such methods as thermal diffusion and chromatography are reported, along with thermal diffusion studies on transport properties and intermolecular potentials. A computer program for the calculation of multicomponent isotope separation cascades was applied to krypton. Vapor pressure thermometry research on helium and a helium distillation column are also discussed. (P.C.H.)

**1420** (ORNL-3948) CALCULATED MAXIMUM TEMPERATURES OF SPENT YANKEE ATOMIC TYPE POWER REACTOR FUEL DURING SHEAR-LEACH PROCESSING. Abraham II, G. E.; Finney, B. C. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 81p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Methods were developed and used to calculate the maximum temperatures of a spent Yankee Atomic type power reactor fuel subassembly (thirty-six 0.305-in.-OD by 102-in.-long stainless steel fuel rods on 0.422-in. centers) during shear-leach processing and to calculate pressure buildup within a batch dissolver as the hot fuel is quenched by cold nitric acid in preparation for aqueous processing. The following five cases, related to unit operations of shear-leach were investigated: fuel subassembly suspended vertically in water; subassembly suspended horizontally in air; subassembly contained within the shear feed envelope; sixteen 5-, 7¾-, or 10-in.-ID baskets of sheared fuel stored in a 4 by 4 array on 12-in. centers; leaching of six baskets in a batch dissolver. Temperatures were calculated over a range of burnups of 8000 to 50,000 Mwd/metric ton (U), specific powers of 10 to 70 watts per gram of uranium, and decay times of 180 to 1080 days. For any given condition of burnup, specific power, and cooling time, the maximum temperature occurs at the center line of the baskets of sheared fuel. The center-line temperatures varied from 160°F at a burnup of 8000 Mwd/metric ton, specific power of 10 w/g, and 1080 days of cooling for the 5-in.-ID basket, to 1585°F for the 10-in.-ID basket at a burnup of 50,000 Mwd/metric ton, specific power of 70 w/g, and 180 days of cooling. Maximum acid feed rates to the dissolver, which would result in a 1-psig pressure in the dissolver disengaging space varied from $10^5$ to $10^7$ lb/hr for the range of burnups, specific powers, and cooling times investigated. Since these rates are impractical, pressure buildup will not present a hazard in the operation of the dissolver. Computer code BIGDEAL, written in FORTRAN language, was used to make all calculations; it is applicable to either the CDC 1604 or the IBM 7090 computer. (auth)

**1421** (ORNL-3965) TRANSURANIUM QUARTERLY PROGRESS REPORT FOR PERIOD ENDING OCTOBER 31, 1965. Burch, W. D. (comp.) (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 93p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

Developments in separation processes for the transuranium elements, process equipment development, HFIR target fabrication development, construction of the Transuranium Processing Plant, corrosion studies, and analytical research and development are reported. (P.C.H.)

**1422** (ORNL-3987) RECOVERY OF THORIUM (AND URANIUM) FROM GRANITIC ROCKS. Hurst, F. J.; Crouse, D. J.; Brown, K. B. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 88p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Based on an acid leach-solvent extraction flowsheet, total estimated recovery costs for Th and U from granite ranged from about $230 per lb of Th + U recovered for some average-grade granite samples to $16 for the richest and most amenable of the samples. Estimated recovery costs from Conway granite samples ranged from $16 to $62 and are expected to average about $35 per lb of Th + U for the outer 1000 feet of the main formation. These estimated costs include allowance for federal taxes and profit. (P.C.H.)

**1423** (ORNL-3988) ESTIMATED COSTS FOR PROCESSING GRANITES FOR RECOVERY OF THORIUM AND URANIUM. Hurst, F. J.; Crouse, D. J.; Brown, K. B.; Ross, A. H. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 30p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Costs are estimated for recovering thorium and uranium from granitic rock by an acid leach–solvent extraction process. The estimated capital costs for mining-milling operations capable of handling 100,000 tons of ore per day are $150,880,000, assuming no waste in mining, and $201,223,000, assuming a waste : ore ratio of 1 : 1 in mining. The estimated costs for treating granites range from $2.38 to $4.01 per ton of ore, depending on the assumed waste : ore ratio and the acid consumption. (auth)

**1424** (ORNL-3994, pp 27-39) ISOTOPE CHEMISTRY. (Oak Ridge National Lab., Tenn.).

A micromethod was developed for the quantitative determination of dibenzoylmethane and other weak acids by titration in anhydrous ethylenediamine or pyridine. A bimetallic electrode system consisting of anodized platinum and cathodized antimony was used to determine the end point potentiometrically. The titrant was tetrabutylammonium methylate in 90% benzene–10% methanol. A determination was made of the temperature dependence of the isotopic equilibrium constants for the reaction donor $\cdot {}^{11}BF_3 + {}^{10}BF_3 =$

donor $\cdot {}^{10}BF_3 + {}^{11}BF_3$, where the donors were $Me_2S$ and $Bu_2S$. The equilibrium constants are given by $\log K_{eq}(Me_2S) = 10.72/T - 0.01976$ and $\log K_{eq}(Bu_2S) = 9.639/T - 0.01816$. The fractionation of boron isotopes, $(^{10}B/^{11}B)$complex/$(^{10}B/^{11}B)$gas, in the reaction, $C_6H_5OCH_3 \cdot BF_3 \xrightarrow{50\%} C_6H_5OCH_3 + BF_3$, was 1.04 at 25°C, a value only slightly larger than that for the equilibrium isotopic exchange reaction. Experimental values of $k^{12}/k^{13}$ for the carbon kinetic isotope effect in the depolymerization of paraldehyde are 1.006 at 64 and 1.012 at 69°C. No addition compound was formed between CO and $BF_3$, $BCl_3$, or $BBr_3$. The nitrogen kinetic isotope effect, $k^{14}/k^{15}$, for the alkaline reduction by Fe(II) of $NO_2^-$ to $NH_3$ was 1.075 ± 0.004 at 25°C. The corresponding value for the reduction of $NO_2^-$ and $NH_2OH$ to $NH_3$ was 1.032 ± 0.002. Isotope effects in good agreement with these values were computed on theoretical grounds, assuming cleavage of an N–O bond as the significant kinetic step in the reduction of each species. The inverse isotope effect previously observed in the reduction of $NO_2^-$ to $NH_3$ by Fe(II) in the presence of MgO was explained in terms of competing reactions, which produced $N_2O$ instead of $NH_3$. The Oxygen-17 Facility operated continuously during the year except for one interruption on November 28 when an electrical transformer ignited. The peak concentrations of $^{17}O$ and $^{18}O$ in the system reached 24.0 and 99.8%, respectively. Several hundred grams of isotopically enriched $H_2O$ and $O_2$ were made available for distribution to prospective users. Raman spectra were obtained for a number of interhalogen ions. Raman and infrared spectra were observed for $^{10}BF_3 \cdot (CH_3)_2S$ and $^{11}BF_3 \cdot (CH_3)_2S$ in the liquid state. The equilibrium constant for the exchange of boron isotopes between $BF_3$ and $BF_3$-dimethyl sulfide complex was calculated and compared with experiment. The isotopic separation factors for carbon, oxygen, and boron isotopes were computed using spectral data for several systems involving borine carbonyl. Five fundamental vibrational frequencies associated with regular octahedral symmetry (point group $O_h$) were observed in the infrared and Raman spectra of crystals containing $SiF_6^{2-}$, $GeF_6^{2-}$, and $SnF_6^{2-}$ ions. Evidence was obtained from nuclear magnetic resonance spectra for a second addition compound between $BF_3$ and $(C_2H_5)_2O$ existing at temperatures below –30°C. Only a single peak was observed in the NMR spectrum of $BrF_3$. NMR measurements on acid solutions containing Sn(IV) and $F^-$ indicated that a large number of fluorine-containing species are present, which exchange slowly enough for their $^{19}F$ resonance to be observed. The $^{19}F$ NMR spectra of $SbF_5$ and $AsF_5$ were observed at several temperatures. Chemical shifts and a spin-spin coupling constant were measured for an addition compound between $SbF_5$ and $CF_3COOH$. Studies were made of the uses and effects of Coriolis coupling and centrifugal distortion constants in force-constant determinations. Similar studies were made of the use of mean square amplitudes of vibration from electron diffraction studies of gases. Several existing computer programs were modified to permit the extraction of Coriolis coupling and anharmonic constants from the experimental data by the method of least squares. More than 900 samples of $O_2$, $N_2$, $CO_2$, and $BF_3$ were analyzed for isotopic composition. (M.C.G.)

**1425** (ORNL-3995) CHEMICAL TECHNOLOGY DIVISION, UNIT OPERATIONS SECTION QUARTERLY PROGRESS REPORT, JANUARY–MARCH 1966. Whatley, M. E.; Haas, P. A.; Horton, R. W.; Ryon, A. D.; Suddath, J. C.; Watson, C. D. (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 75p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Five sections are included; a separate abstract was prepared for each. (P.C.H.)

*For abstracts of individual sections see: 1426–1430.*

**1426** (ORNL-3995, pp 4–20) CHEMICAL ENGINEERING RESEARCH. (Oak Ridge National Lab., Tenn.).

Recently, the experimental stacked-clone solvent-extraction contactor has been operated with the organic phase continuous. All previous work was done with the aqueous phase continuous. Demonstration of the organic-continuous mode of solvent extraction extends the range of usefulness of the contactor to allow operation at very low aqueous : organic flow ratios and with highly viscous aqueous solutions. Organic-continuous dispersions were produced, and flooding throughputs were measured for a variety of chemical systems including Amsco–0.08 M $HNO_3$, Amsco–66 wt % glycerine, and Amsco–38.5 wt % dextrose. Mass transfer of uranium was measured for a 5% TBP–Amsco–1 M $NaNO_3$ system. Finally, the effect of sudden injections of particulate impurities on contactor operation was noted for both aqueous- and organic-continuous modes of operation. (auth)

**1427** (ORNL-3995, pp 21) PROCESSING OF POWER-REACTOR FUELS. Finney, B. C.; Watson, C. D. (Oak Ridge National Lab., Tenn.).

The development and evaluation of a batch shear-leach process for recovering fissile and fertile materials from spent power-reactor fuel assemblies were continued. The packing density and void fraction of sheared and leached sections of 0.5-in. × 1-in. -long tubing was determined to be 1.2 kg/l and 85%, respectively. Typically, for each metric ton uranium processed, about 100 gal of empty metallic hulls will be produced for a fuel of the type used in the Nuclear Merchant ship Savannah. (P.C.H.)

**1428** (ORNL-3995, pp 22-8) THORIUM FUEL-CYCLE STUDIES. Haas, P. A. (Oak Ridge National Lab., Tenn.).

Development of sol-gel processes for recycling thorium and uranium to heterogeneous reactors has continued, with emphasis on the preparation of oxide spherules. Cracking of the oxide microspheres during firing depends on the gel-drying conditions and is more troublesome for larger microspheres. The presence of superheated steam in the drying atmosphere as the temperature increases from 100 to 200°C aids in removing 2-ethyl-1-hexanol from the gel and reduces the amount of cracking during firing. A pilot-plant-scale microsphere column system was operated at rates up to 1200 g of $ThO_2$ per hour to produce microspheres for pyrolytic-carbon-coating studies. The microspheres were in two size ranges: 210 to 250 μ, and from 420 to 500. Operation of the column was good, but operation of the auxiliary equipment was less satisfactory. (auth)

**1429** (ORNL-3995, pp 29–35) SOL-GEL PROCESS DEVELOPMENT. Haas, P. A. (Oak Ridge National Lab., Tenn.).

Engineering studies of urania-sol preparation were continued as part of the sol-gel process development for preparing ceramic fuel mixtures. The photochemical reduction of $UO_2^{2+}$ to $U^{4+}$ in uranyl nitrate solution by hydrazine or formaldehyde was never more than 46% complete; no further work is planned. The direct, catalyzed reduction of uranyl formate suspensions (one-step process) gave 70% conversion of the uranium to urania sols in 4 to 5 hr. Conditioning of the platinum catalyst (adsorption of hydrogen on wetted catalyst) was necessary. Higher yields and lower formate : urania ratios would be required to make this procedure attractive, compared with others. The equipment and procedures proposed for use in glove boxes to prepare $UO_2$–$PuO_2$ microspheres were successfully tested with depleted $UO_2$ sols. (auth)

**1430** (ORNL-3995, pp 36–70) FLUORIDE VOLATILITY PROCESSING. Horton, R. W. (Oak Ridge National Lab., Tenn.).

Four tests were made of the HF–$O_2$ decladding process; one was successful and three were not. The explanation for the unsuccessful tests is not yet known. Heating-rate experiments indicate that the fuel element reaches reaction temperature readily with any one of several fluidizing bed materials. When the oxides, left after decladding, were fluorinated, 99.6% of the uranium was volatilized from the fluidized bed. Requirements have been established for in-line analytical instruments. A gas chromatograph and an ultraviolet spectrophotometer are now installed. Data taken by these two instruments during process and calibration runs are shown. A method was considered for using the delayed neutron flux from plutonium following a neutron irradiation burst to detect the presence of residual plutonium in the reactor waste. From a radiation experiment and from published values of the concentration of transplutonium elements that would produce an interfering neutron flux, it was concluded that the method is not likely to justify the development and installation cost. (auth)

**1431** MECHANISM OF EXTRACTION OF QUADRI- AND SEXIVALENT URANIUM SULFATES WITH TRI- AND DI-N-OCTYLAMINE. Zvyagintsev, O. E.; Frolov, Yu. G.; Sudarikov, B. N. Tr. Moskov. Khim.-Tekhnol. Inst., No. 47, 134-9(1964). (In Russian).

The extraction of quadri- and sexivalent uranium sulfates using tri- and di-n-octylamine was studied at 20°C. The extraction depended on amine concentration and the $H_2SO_4$ concentration. The extraction of U(IV) decreased sharply with increasing $H_2SO_4$ concentration to 0.3N then decreased at a slower rate. The U(VI) extraction decreased slightly with increased $H_2SO_4$ concentration. The extraction was examined in mixtures of the amines, and the extraction by mixtures was the sum of the extractions by each amine. (D.H.M.)

**1432** USE OF RADIOACTIVE TRACER TECHNIQUE IN HIGH VACUUM FOR CONSTRUCTION OF A MASS SEPARATOR-COLLECTOR FOR XENON. Dobrozemsky, R.; Hechtl, E.; Viehboeck, F. P. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 70-5(1966). (In German).

The principle of an activated-carbon adsorption collector for the collection of Xe in the production of high-purity $^{131}Xe$ is described. The adsorption isotherm for Xe on activated C was measured at –196°C using the radioactive tracer technique. The results showed that activated C is suitable for the adsorption of Xe at the temperature of liquid N. The construction of the collector is described. (J.S.R.)

**1433** STUDY OF THE EXTRACTION OF $U^{6+}$ BY SOLUTIONS OF TRI-N-OCTYLAMINE IN THE PRESENCE OF $Fe^{2+}$ AND $Mn^{2+}$ IONS. Medvedeva, E.; Starobina, T. M.; Gromov, B. V. Tr. Moskov. Khim.-Tekhnol. Inst., No. 47, 145-50(1964). (In Russian).

Extraction studies of $Fe^{2+}$ solutions with $(C_8H_{17})_3N$ at an amine: Fe ratio of 3, pH 1.0, Fe concentration of ~8 g/l in the aqueous phase, and 20°C indicated a maximum distribution coefficient of ~0.22, and the amount of Fe in the organic phase increased with increasing Fe concentration. The distribution coefficient increased with increasing pH up to 1.7 and then remained constant to pH 3.0. For solutions >0.1M Fe, the distribution coefficient decreased with increasing U concentrations over the range from 0 to 4.1 g/l; while for solutions <0.1M Fe, the distribution coefficient decreased with increasing U concentration up to ~2.9 g/l. In all cases the extraction of U was decreased by the presence of Fe. Manganese was not extracted by the amine either in the presence or absence of U; however, the effect of Mn on the extraction of U was pH dependent. At pH 0.5, the distribution coefficient of U was only slightly dependent on the Mn concentration, but at pH 2.0 $K_U$ increased sharply with increasing Mn to 0.018M and then decreased. At pH 1.0 and 0.1M Mn, $K_U$ was temperature dependent and increased with increasing temperature to 60°C and then decreased. (B.L.M.)

**1434** KINETICS OF REEXTRACTION OF U(IV) FROM TRI-N-OCTYLAMINE SOLUTIONS IN BUTYLBENZENE BY AQUEOUS SOLUTIONS OF HYDROFLUORIC ACID. Nazarov, A. S.; Gromov, B. V. Tr. Moskov. Khim.-Tekhnol. Inst., No. 47, 165-73(1964). (In Russian).

Reextraction studies of solutions of U(IV) in 0.22M $(C_8H_{17})_3N$ with HF indicated that the extracted compound did not form at the phase boundary, but in the organic phase. Reextraction increased with increased mixing rate and with increased U concentration up to 820 rpm and then became constant. At mixing rates <820 rpm, the degree of reextraction was independent of U concentration but directly dependent on HF concentration. For constant amounts of HF and U(IV), the reextraction increased slightly with increasing volume of organic phase decreased with increasing volume of aqueous phase. With the addition of some HCl (1.74M HF + 2.5M HCl) the reextraction increased with increased mixing rates up to 1200 rpm. The apparent rate constant increased with increasing concentration of U in the organic phase. (B.L.M.)

**1435** PROCESS OF REEXTRACTION STUDIED BY A CHROMATOGRAPHIC METHOD. Nazarov, A. S.; Gromov, B. V. Tr. Moskov. Khim.-Tekhnol. Inst., No. 47, 159-64(1964). (In Russian).

A chromatographic method is reported for using 0.2M HF to reextract the U(IV) from an organic phase obtained by extracting $H_2SO_4$ solutions of U with 0.12 and 0.22M $(C_8H_{17})_3N$. The organic phase was supported on Teflon powder and portions of HF were passed through the column. Formation of $UF_4$ did not begin until the F : U ratio equaled 3, and for each 2 moles of HF adsorbed (up to F : U = 2) a mole of $H_2SO_4$ is librated into the aqueous phase. This along with the absorption isotherm of HF confirmed the stepwise character of the $UF_4$ formation. An explanation is offered for why the extraction capacity of the organic phase for U is less after reextraction. (auth)

**1436** SEPARATION OF CLOSELY RELATED ELEMENTS BY PRECIPITATION BY MEANS OF DECOMPLEXING AND REDOX REACTIONS. Pajakoff, Sw. (Technische Hochschule, Vienna). Mikrochim. Acta, No. 4-5, 751-61(1966). (In German).

The combination of selective thermal decomposition, extraction, and decomplexing as well as consideration of the interfacial and redox reactions were studied for separating elements that are closely related chemically. Compounds such as oxyfluorides, fluorides, phosphates, higher valence hydroxides, carbonates, oxy- and hydroxy compounds with carboxylic and aminopolycarboxylic acids, as well as compounds with mixed ligands, can be prepared by means of exchange, displacement, and redox reactions. The effectiveness of the described methods is shown by several examples such as Zr–Hf, La–Pr, Pr–Nd, and Ce–Pr–Nd. (auth)

**1437** SEPARATION OF ZIRCONIUM AND NIOBIUM WITH DI-n-OCTYLMETHYLENE-BIS-PHOSPHONIC ACID. Gorican, H.; Djordjevic, C. (Institut Ruder Boskovic, Zagreb. Naturwissenschaftlichen Fakultaet, Zagreb). Mikrochim. Acta, No. 4-5, 767-70(1966). (In German).

The separation of $^{95}Zr$ and $^{95}Nb$ by extraction using di-n-octylmethylene-bisphosphonic acid is described. The elements were separated from each other from dilute solutions ($<10^{-4}$M) and also from carrier-free solutions. The relation of the distribution coefficients to the acid concentration and the concentration of the reagent was studied. (auth)

**1438** THE INSTITUTE OF STABLE ISOTOPES AT LEIPZIG. Muehlenpfordt, J. Isotopenpraxis, 2: 113-16(Mar. 1966). (In German).

The Institute of Stable Isotopes at Leipzig is divided into 7 sections: methods of isotope separation, electromagnetic isotope separation, chemical methods of isotope separation, chemistry and geology, physiology and biochemistry, mass spectrometry, and special methods of isotope analysis. The work done by these sections is briefly summarized by means of a literature review. (J.S.R.)

**1439** STUDY ON OBTAINING OF SAMARIUM CONCENTRATIONS FROM CERIA EARTH BY HOMOGENEOUS PRECIPITATION. Hubicki, Wlodzimierz; Dabkowska, Michalina; Cygan, Janina (Universitatis Marie Curie-Sklodowska, Lublin). Ann. Univ. Mariae Curie-Sklodowska, Lublin-Pol., Sect. AA, 19: 59-68 (1964). (In Polish).

Homogeneous precipitation of double sulfates to obtain samarium concentrates from ceria-free and lanthanum-poor rare earth oxides was studied. Ammonium sulfate in the presence of urea at room temperature very slowly precipitated lanthanum ammonium double sulfate; at 60°C the precipitation proceeded much faster, but incompletely. Step-wise addition of sodium nitrate to the filtrate caused the precipitation of addiational fractions. This method led to a series of fractions with enriched samarium contents and in which the content of heavy lanthanides simultaneously increased. The initial material contained 16% $Sm_2O_3$ and the fourth fraction contained 23% $Sm_2O_3$. From solutions of rare earth chlorides (500 g/l) complexed 50% with hydroxyethylethylenediaminotriacetic acid and heated to 60°C with ammonium sulfate, precipitates formed slowly and the samarium content in the filtrate increased at pH = 7. At pH = 3, enrichment occurred in the precipitate and the filtrate contained no samarium. From solutions of rare earth acetates, which were mixed with stoichiometric amounts of $Na_2S_2O_8$ and heated to 70°C, ammonium lanthanum double sulfates were precipitated. The samarium content in the individual fractions increased with 17% $Sm_2O_3$ in the initial material and 27% in the first four fractions. A continuation of the operations led to 30% samarium concentrations. In heated solutions of rare earths, containing urea and $Na_2S_2O_8$, the precipitation process went slower than in the absence of urea; the enrichment of samarium was lower with only 25% $Sm_2O_3$ occurring in the first four fractions. (J.S.R.)

**1440** SOLVENT EXTRACTION OF CHELATE COMPOUND OF PLUTONIUM(IV) WITH 1-PHENYL-3-METHYL-4-BENZOYLPYRAZOLONE-5. Zolotov, Yu. A.; Chmutova, M. K.; Palei, P. N. Zh. Anal. Khim., 21: 1217-22(1966). (In Russian).

The extraction of plutonium (IV) chelate compound with 1-phenyl-3-methyl-4-benzoylpyrazolone-5 (PbMBP) from nitric, hydrochloric, and sulfuric acid solutions was investigated. Plutonium is quantitatively extracted with a 0.1 M solution of PhMBP in Benzene from 1–7 N solution of $HNO_3$ and almost quantitatively extracted from 1–7 N solutions of $H_2SO_4$. The effect of solvents, of the concentration of PhMBP and plutonium and of foreign complex forming substances on plutonium extraction from nitric acid solutions was studied. Large amounts of acetates, oxalates, citrates, and phosphates do not interfere with the extraction. Conditions for the back extraction of plutonium were found. The complex formation of plutonium with PhMBP was studied; the stability constants of the complexes were determined. (auth)

**1441** EXTRACTION OF Pu(IV) WITH TRIHEXYLPHOSPHINOXIDE AND A MIXTURE OF Di-n-BUTYLPHOSPHORIC ACID AND TRIHEXYLPHOSPHINOXIDE. Kuca, L. (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Collect. Czech. Chem. Commun., 31: 4064-71(Oct. 1966).

In extraction using the system trihexylphosphineoxide (THPO)–$CCl_4$–1M–$HNO_3$ the complex $Pu(NO_3)_4 \cdot 2$ THPO was formed with an extraction constant log K = 5.98 ± 0.1. In the system dibutylphosphate (HDBP)–THPO–$CCl_4$–1M–$HNO_3$ the formation of mixed complexes was studied within the concentration range $1.5 \times 10^{-3}$ to $10^{-5}$M-HDBP and $10^{-2}$ to $10^{-4}$M-THPO. A single complex of the composition $Pu(NO_3)_2(DBP)_2$ THPO was formed with the extraction constant log K = 15.0 ± 0.6. (auth)

**1442** PREDICTION OF THE APPROACH TO STEADY STATE OF A MIXER-SETTLER EXTRACTOR. Halligan, James E.; Smutz, Morton (Ames Lab., Ames, Iowa). Sep. Sci., 1: 173-90 (1966). (IS–1248).

At present there is no reliable method of predicting the time required for a cascade of mixer-settler stages to approach steady state. Rules of thumb are used, based on the number of throughputs of the various streams. Data obtained in the laboratory for the TBP (tributyl phosphate)-Varsol-$H_2O$-$HNO_3$ system are compared with four assumed mathematical models. It was found that the model that assumed homogeneity of the aqueous phase in the set-

tling chamber and plug flow of the organic phase in the settling chamber predicted the nitric acid concentrations most accurately. In the absence of other information, this model is recommended for prediction of results for tube-type mixer-settler extractors for systems with similar properties. It was of considerable interest that simpler models could be used for accurate estimates when the number of stages in the cascade was increased. (auth)

**1443** SORPTION OF THE RADIOISOTOPES $^{35}S$, $^{131}I$, AND $^{106}Ru$ ON HYDRATED OXIDES IN LABORATORY COLUMNS. Kepak, F. (Inst. of Nuclear Research, Academy of Sciences, Rez, Czech.). Collect. Czech. Chem. Commun., 31: 3500-11(Sept. 1966).

Sorption of $^{35}S$ as the sulfate ion on hydrated aluminum oxide, $^{131}I$ as the iodide ion, $^{106}Ru$ as the ruthenium(III)- and nitrosylruthenium(II)-ion on hydrated ferric oxide, containing a small amount of silver oxide was studied under dynamic conditions. The sorption of $^{106}Ru$ was also studied under static conditions and it was observed that the absorption of a small quantity of silver oxide in ferric oxide increased its sorption capacity for the ruthenium(III)- and nitrosylruthenium(II)-ion and the sorption was characterized by high values of the distribution coefficient. The results of the column experiments showed that this technique is suitable for removing $^{35}S$ from aqueous solutions on aluminum oxide, $^{106}Ru$ on ferric oxide, containing silver oxide, sorption of $^{131}I$ was less effective in columns of this sorbent. (auth)

**1444** STUDY OF STRIPPING URANIUM COMPLEX FROM AN AMINE EXTRACT WITH AQUEOUS SALT SOLUTIONS. Jickling, R. S.; Diez, Gerhard; Van Cleave, A. B.; DeCoursey, W. J. (Univ. of Saskatchewan, Saskatoon). 23p. (CONF-660636-1). ORAU. Gmelin, AED-CONF-66-183-1.

From 49th Canadian Chemical Conference, Saskatoon, Canada.

The organic phase produced by extraction of a uranium leach liquor with Amberlite LA-2 in kerosene was stripped of uranium in laboratory tests with solutions of NaCl and $H_2SO_4$ or solutions of $Na_2SO_4$. It was found that $NaCl-H_2SO_4$ stripping reduced considerably the effectiveness of the solvent for subsequent extraction, whereas $Na_2SO_4$ stripped the uranium content without any deleterious effect. Optimum $Na_2SO_4$ concentration and pH for stripping were determined. Phase separation time and entrainment losses appeared satisfactory. (auth)

# EARTH SCIENCES

## Geology

*Refer also to abstracts 1328 and 1485.*

**1445** (CEA-R-3017) EMISSIONS GAMMA DE QUELQUES METEORITES ET ROCHES TERRESTRES EVALUATION DE LA RADIOACTIVITE DU SOL LUNAIRE. (Gamma-Emissions of Some Meteorites and Terrestrial Rocks; Evaluation of Lunar Soil Radioactivity). Nordemann, Daniel (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1966. 105p. Dep. mn.

Thesis. Submitted to Paris Univ., France.

The gamma-emissions of some terrestrial rocks and of the meteorites Bogou, Eagle-Station, Granes, and Dosso were studied by quantitative low background gamma spectrometry. These measurements and their interpretation lead to the evaluation of the possible gamma-emissions of several models of lunar soils. (tr-auth)

**1446** (JUL-379-ST) UMWELTRADIOAKTIVITAET DER KERNFORSCHUNGSANLAGE JUELICH. (Environmental Radioactivity of the Juelich Nuclear Research Center). Vogt, K. J.; Jacobs, H.; Polster, G. (Kernforschungsanlage, Juelich (West Germany). Zentralabteilung Strahlenschutz). Apr. 1966. 88p. Dep. mn.

Results from radioactivity monitoring of atmosphere, water, soil, and milk at Juelich in 1965 are presented in tabular and graphic form. (J.S.R.)

**1447** URANIUM DISTRIBUTION IN SOME GRANITOID INTRUSIONS OF THE ALTAI. Dolgushin, S. S.; Amshinskii, N. N. (Scientific Research Inst. of Geology, Geophysics, and Mineral Resources, Novosibirsk, USSR). Geokhimiya, No. 9, 1081-6(Sept. 1966). (In Russian).

The log-normal distribution of uranium, the change of its content, and the character of the distribution irregularity with depth was established. The data obtained were used to compare the massifs with one another according to the depths of the erosional section. (auth)

**1448** ALPHA SPECTROMETRY OF RADIOACTIVE ROCKS. Vittozzi, Pio (Univ., Naples). Ann. Osserv. Vesuviano, 6: 85-112(1964). (In Italian).

The law of variation of the number of emergent $\alpha$ particles with respect to the path of the particles is determined for emitting layers of small thickness compared to the range of the particles in the layers. The law is applied to the calibration of an ionizing chamber connected with a 100-channel analyzer and to the $\alpha$ spectra obtained by this device. The functions are presented in tabular and graphical form. Data for detection of Rn where the thickness is 0.1 the path length are graphed. The detection of various members of the Ra and Th families is illustrated; with samples of recent Vesuvian lava, data are shown for particles assuming a $2\mu$ path in the sample, and for particles of lower energy. A method of determining $\alpha$ spectra is developed and illustrated, using a sample of Th whose analysis by other means confirms the utility of the method. (BBB)

**1449** MEASUREMENT OF SNOWPACK PROFILES WITH RADIOACTIVE ISOTOPES. Smith, James L.; Willen, Donald W.; Owens, Michael S. (Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.). Weatherwise, 18: 247-51; 257 (Dec. 1965).

Neutron and $\gamma$ backscatter gages can be used to measure profiles of snow density, but backscatter systems cannot locate density changes accurately within their 12- to 16-in. sphere of measurement, and they are not reliable within 12 in. of the snow surface because of loss of energy to the air. A new system was developed to eliminate these problems. A two-probe $\gamma$ transmission system was designed for accurate measurement of the mass per unit volume of $\frac{1}{2}$ in. horizontal layers of material. The probes are lowered into parallel access tubes 12 in. apart in the snowpack. Radioactivity is emitted from a 5-mC $^{137}Cs$ source sealed in the end of a source-holder rod lowered into one of the access tubes. The detector probe consists of a sodium-iodide crystal scintillation detector, a photomultiplier tube, transistorized preamplifier, and cable. The source and detector can be raised or lowered simultaneously within the 2 access tubes. The complete system is portable and battery-operated and weighs about 30 lb. The system measures snow density to within ±1.2% of actual density, and is able to detect changes in density faithfully. Results obtained with this new system are shown. (BBB)

**1450** OXYGEN ISOTOPE FRACTIONATION IN METAMORPHOSED IRON FORMATIONS OF THE LAKE SUPERIOR REGION AND IN OTHER IRON-RICH ROCKS. James, H. L.; Clayton, R. N. (Univ. of Chicago). pp 217-39 of Petrologic Studies: A Volume to Honor A. F. Buddington. New York, Geological Society of America, 1962.

The $^{18}O/^{16}O$ ratios of some Precambrian rocks of northern Michigan, Wisconsin, and Minnesota were examined. The principles of isotopic thermometry are presented as well as some analytical procedures for determining $^{18}O/^{16}O$ values of geological specimens. Oxygen isotopic compositions of magnetite, hematite, quartz, and calcite from some of the metamorphosed iron formations were measured. Mineral pairs such as quartz-hematite and calcite-hematite have $^{18}O/^{16}O$ differences that bear consistent relation to inferred thermal gradients in the lower metamorphic zones. By relating the observed isotopic fractionation to the experimentally derived fractionation curve for $CaCO_3-H_2O$, it was possible to estimate that apparent temperatures of last crystallization reached about 200°C in the chlorite zone, 275°C in the biotite zone, and 350°C in the garnet zone. The indicated temperatures for rocks formed at temperatures above that of the garnet zone do not show a similar consistent pattern; this is attributed largely to retrograde equilibration during the cooling period. The waters involved in metamorphism average about +0.1% $^{18}O/^{16}O$ in the chlorite zone. This value increases abruptly in the biotite and higher zones to about +0.5%, probably because of exchange with enclosing rocks at higher temperature. The $^{18}O/^{16}O$ data for deposits include some for minerals with very low temperature of origin (Balmat, New York, 90°C) and some for minerals with very high temperature of origin (Iron Springs, Utah, 710°C). (BBB)

**1451** FACTORS AFFECTING THE CHOICE OF SITES FOR NUCLEAR POWER STATIONS. Mandel, Heinrich (Rheinisch-Westfaelisches Elektrizitaetswerk AG, Essen). Brennstoff-Waerme-Krafts, 18: 493-8(Oct. 1966). (In German).

The choice of site for a nuclear power station is influenced by many factors, the relative importance of which must be considered in order to reach an optimum conclusion. Particularly important are the geological conditions at the site, the meteorological conditions, the geographical location, the hydrology, and the location with respect to the power network. The supply of cooling or make-up water often presents difficulties even with recooling operation. The effect on the costs of generation must therefore be carefully considered. Account must also be taken of the economical cooperation of all power stations feeding into an interconnected network. The greater flexibility of nuclear power stations compared to conventional thermal power stations as regards the choice of site is discussed. (auth)

**1452** ISOTOPIC AND LEAD-ALPHA AGES OF SOME AUSTRALIAN ZIRCONS. Richards, J. R. (Australian National Univ., Canberra); Berry, H.; Rhodes, J. M. J. Geol. Soc. Australia, 13: 69-96(1966).

The $^{208}Pb/^{206}Pb$, $^{235}U/^{238}U$, and $^{230}Th/^{232}Th$ ratios were measured in the course of age determinations on zircons from 3 areas in the Australian Precambrian. Three samples, from the Rum Jungle Complex, basement to the Pine Creek Geosyncline, yield an extrapolated age of 2550 Myr. This result, in conjunction with evidence concerning the age of intrusive granites, enables preliminary time limits, 2550 Myr to about 1700 Myr, to be assigned to the period of sedimentation in this geosyncline. Results from the Mount Isa area support geological deductions that the oldest phases of the Sybella Granite are remnants of basement rocks, approximating in age the Ewen Granite at around 1780 Myr; that the Wonga Granite may well be derived from sediments older than the tectonic event reflected in the 1300 to 1450 Myr K-Ar ages observed in this region; and that the Wimberu Granite may belong to a later event, but older than that indicated by the biotite ages. Zircon from metasedimentary gneiss underlying the Ravensthorpe System in Western Australia yields an age of 2800 Myr equivalent to that of the intrusive pegmatite at Cattlin Creek. This suggests that the metamorphism dated at 2800 Myr caused complete loss of all previously accumulated lead from this older material. (BBB)

**1453** ISOTOPIC CARBON COMPOSITION OF $CO_2$ OF THE SOIL. Galimov, E. M. (Moscow Inst. of Oil-Chemical and Gas Industry). Geokhimiya, No. 9, 1110-18(Sept. 1966). (In Russian).

The isotopic carbon composition of carbon dioxide from soils of various types was studied. On the basis of obtained experimental data, possible processes of carbon isotope separation in soil are discussed. (auth)

# Meteorology

*Refer also to abstracts 1284 and 1451.*

**1454** (AAEC-TM-317) PRELIMINARY REGIONAL STUDY OF SURFACE RADIOACTIVITY IN THE BROKEN BAY-ILLAWARRA-KATOOMBA AREA. Mumme, I. A.; Duggleby, J. C.; Finn, R.J.; Parsons, D. E. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Apr. 1966. 22p. Dep. mn.

Natural background radiation has been measured along typical road traverses in the environs of Sydney and Lucas Heights. Soil samples were taken and radioactive elements identified by gamma spectrometry. The gamma-ray dose rates were in the range 20 to 40 mR/year though higher and lower values were recorded. The normal gamma-ray intensities at the surface were generally related to the nature of the underlying weathered rock formations. The characteristic dose rates are listed. (auth)

**1455** (AD-640491) THREE TESTS OF FIREHOSING TECHNIQUE AND EQUIPMENT FOR THE REMOVAL OF FALLOUT FROM ASPHALT STREETS AND ROOFING MATERIALS. Wiltshire, L. L.; Owen, W. L. (Naval Radiological Defense Lab., San Francisco, Calif.). Jan. 17, 1966. 70p. (USNRDL-TR-1048). CFSTI $3.00 cy, $0.75 mn.

Three separate firehosing experiments are described. Each employed radio-traced simulant in order to measure removal effectiveness. Two of the experiments, which were conducted on asphalt streets, concluded the test series started in 1963. The first experiment investigated the feasibility of the NRDL flare nozzle as a reclamation tool for paved surfaces. The second experiment consisted of the full scale reclamation of a street area. This provided operational data and firehose-crew exposure-rate histories. The third experiment, which involved the reclamation of roof surfaces, was a renewal of earlier work performed by this laboratory between 1952 and 1958. New roofing materials were tried and particle size effects were measured. It was concluded that: effectiveness of reclamation by firehosing improves as surface roughness decreases and particle size increases; removal effectiveness improves with effort, but the residual mass is not significantly reduced after the second pass; the flare nozzle is consistently more effective than the fire nozzle in cleaning roof surfaces but this is not the case for paved surfaces; results from full scale tests show that the removal effectiveness can never equal that achieved under the less realistic operating conditions represented by smaller engineering-scale tests; and exposure reduction factors are not significantly affected by surface roughness, particle size or mass loading. (auth)

**1456** (HNS-457-73F) METEOROLOGICAL EVALUATION OF RADIOACTIVE FALLOUT. Final Report. Kruger, Paul (Hazleton-Nuclear Science Corp., Palo Alto, Calif. Radiochemistry Dept.). June 30, 1966. Contract AT(04-3)-457. 69p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Data obtained from studies of meteorological influences upon $^{90}Sr$ deposition by precipitation from 1960 through 1964 are summarized. Fission product debris, notably $^{90}Sr$, deposited by precipitation is examined under various storm conditions, and the effects of several meteorological parameters are noted. These include the transport processes of the debris from stratosphere to troposphere, the effects of changes in air masses involved in a storm, the effects of changes in precipitation generation and growth mechanisms, stratification across inversions, and the evaporation of raindrops below cloud bases. (auth)

**1457** (RRA-T61 and Summary) GROUND ROUGHNESS CALCULATIONS FOR FALLOUT GAMMA RAYS. Final Report. French, R. L.; Olmedo, L. (Radiation Research Associates, Inc., Fort Worth, Tex.). June 30, 1966. Contract N228(62479)68174. 76p.

A study was made of four models for calculating the effect of ground roughness on gamma energy and angular distribution in air above a fallout field. One model, buried-source model, assumes that a uniform thin layer of soil covers the fallout with the thickness of the layer corresponding to the degree of ground roughness. Another, mixed-source model, assumes that the fallout is mixed with a thin layer of soil. A third model, collimated-source model, assumes that the fallout is deposited on a smooth ground surface but that the gamma emission is constrained to certain angular sectors. The last model, furrowed-surface model, assumes that the fallout is distributed over a ground surface which has uniform concentric circular furrows. Calculations of the energy and angular distributions of the uncollided and the singly scattered fluxes three feet above sources with one or more energies were performed using each of the models. Comparisons with measured data and consideration of the convenience of application indicate that the buried- and mixed-source models are preferable to the other two. The results indicate that the magnitude and the angular distribution of the uncollided flux is strongly influenced by ground roughness. The singly scattered flux, which can actually be increased by ground roughness, is much less sensitive to ground roughness than is the uncollided flux. (auth)

**1458** (TID-23366) IONIZATION DUE TO THE VERY SOFT SEA LEVEL RADIATION. Shamos, M. H.; Siderowitz, J. (New York Univ., N. Y. Dept. of Physics). June 1962. Contract AT(30-1)-1704. 110p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

Measurements of the radiation intensity at sea level (over water) with a thin-wall ionization chamber show the existence of a very soft ionizing radiation, having an ionization density of $(16.2 \pm 2.4) \times 10^{-2}$ ion pairs $cm^{-3}$ $sec^{-1}$ (standard air). This soft radiation accounts for $4.5 \pm 0.5\%$ of the total ionization density, and can be almost completely absorbed by 400 $mg/cm^2$ filter. Freon-12, the chamber gas, provided preferential recombination of the ions in the alpha tracks arising from the natural radioactivity in the chamber wall. The chamber window, $4.54 \times 10^3$ $cm^2$ in area, is made of an aluminized Mylar film, 1.77 $mg/cm^2$ thick, having a low energy cut off of approximately 35 keV for electrons. Measurements made with Al, Fe, and plexiglas filters show no clear Z-dependence, indicating that the soft radiation was due primarily to an electron flux. From the decrease in ionization current with filter thickness it was computed that this flux consisted of approximately $(1.7 \pm 0.9) \times 10^{-3}$ electrons $cm^{-2}$ $sec^{-1}$ below 1.8 MeV. This soft radiation can be accounted for in terms of the soft beta radiation arising from the decay products of Rn normally present in the atmosphere. It was computed that an activity of $10^{-13}$ Ci/l (typical of values reported for the New York City area) would make a contribution of $0.8 \times 10^{-3}$ electrons $cm^{-2}$ $sec^{-1}$ to the flux below 2 MeV. This compares favorably with the flux of $(1.7 \pm 0.9) \times 10^{-3}$ electrons $cm^{-2}$ $sec^{-1}$ determined from the filter study. (auth)

**1459** (TID-23369) MEASUREMENT OF RADIOACTIVE FALLOUT BY FIELD TOTAL ABSORPTION GAMMA RAY SPECTROSCOPY. Report No. 5. Data Analysis for Period, January 1–September 1, 1965. Foote, R. S. (Texas Instruments Inc., Dallas. Science Services Div.). Nov. 26, 1965. Contract AT(40-1)-3147. 94p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Nearly continuous measurement of gamma emission from the ground demonstrated the practicality of an automated remote gamma spectral monitoring system for natural and artificial radioactivity. The equipment is portable and offers the capability of taking "several-minute photographs" of gamma radiation associated with any section of terrain, and supplying data that permits immediate assessment of radionuclide concentration. Gamma ray standard calibration spectra have been measured for those radionuclides comprising the field gamma spectrum. These have been used to reduce the field spectra in calculating the respective amounts of radiation from each radionuclide. Techniques for spectral energy calibration have been improved to minimize errors created by inaccurate energy calibration. Seven major fission-created radionuclide series have been monitored in the field spectrum for their fallout and decay. These include: $^{144}Ce$–$^{144}Pr$, $^{140}Ba$–$^{140}La$, $^{54}Mn$, $^{95}Zr$–$^{95}Nb$, $^{137}Cs$, $^{125}Sb$, $^{131}I$. Initial measurements recorded the presence of fallout from earlier U. S. and Russian atmospheric tests. Later measurements indicated the new fallout from the first and second Chinese Peoples Republic atmospheric nuclear tests. Using the improved calibration technique, data were reprocessed based on one record/day to illustrate the long-term variations in radiation levels of the fission radionuclides. The comparison of this least-squares program results with previous techniques indicates that this method provides minimum error in data reduction. The program for least-squares selection of optimum energy calibration is provided and explained. (TSS)

**1460** (UCRL-13215) NUCLEAR CLOUD SAMPLING SYSTEM. Swetnam, Robert L. (General Dynamics/Pomona, Calif.). [nd]. Contract W-7405-eng-48. 25p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

For Univ. of California Lawrence Radiation Lab., Livermore.

A series of wind tunnel tests and related analytical studies were performed to establish the aerodynamic configuration of a vehicle for obtaining a debris sample from a cloud formed by a nuclear explosion. The vehicle configuration resulting from the program will obtain an isokinetic particulate sample from 40,000 to 90,000 feet altitude with growth capability to over 100,000 feet with only a filter change. A computer program capable of establishing design parameters for a gas sampling system was prepared. The application of the conical shock diffuser to the air sampling mission is believed to be unique to the state-of-the-art. (R.C.K.)

**1461** (WT-1488) DISTRIBUTION, CHARACTERISTICS, AND BIOTIC AVAILABILITY OF FALLOUT, OPERATION PLUMBBOB.

Projects 37.1, 37.2, 37.2a, 37.3, and 37.6. Larson, K. H.; Neel, J. W.; Hawthorne, H. A.; Mork, H. M.; Rowland, R. H.; Baurmash, L.; Lindberg, R. G.; Olafson, J. H.; Kowalewsky, B. W. (California Univ., Los Angeles. Lab. of Nuclear Medicine and Radiation Biology). July 26, 1966. Contract AT(11-1)-34. 281p. Dep. mn. CFSTI $3.00 cy, $1.50 mn.

Significant findings related to the distribution, characteristics, and biological availability of fallout debris originating in the Plumbbob Test Series (1957) at the Nevada Test Site are reported. The use of aerial radiometric survey was adapted to routine radiation surveys and greatly increased the detail, accuracy, and distance of fallout pattern delineation. Isodose rate and time-of-arrival contour maps are presented for seven tower mounted and four balloon mounted shots along with the predominant particle size fraction on several arcs along each fallout pattern. Particles less than 44 microns in diameter contained about 30% of the fallout radioactivity from tower mounted detonations as compared to about 70% from balloon mounted detonations within distances at which fallout arrived by H + 12 hours. Balloon mounted detonations produced fallout debris of higher water and acid solubility than did tower mounted detonations. The percentage of $^{89,90}Sr$ and $^{103,106}Ru$ was higher in fallout particles less than 44 microns in diameter than in larger fallout particles. There was a higher percentage of these radioelements in fallout debris from balloon detonations than from tower detonations. The amounts of water-soluble $^{140}Ba$ and $^{89,90}Sr$ deposited by a balloon mounted and a tower mounted detonation of similar yield and height of burst were estimated to be similar despite relatively large differences in the total amounts of these radioisotopes deposited. Within distances at which fallout occurred by H + 12 hours, balloon mounted detonations deposited a maximum of 0.13% of the theoretical total of $^{89}Sr$ produced while tower mounted detonations deposited a maximum of 2%. Tower mounted detonations deposited a maximum of 7.2% of the theoretical total amount of $^{90}Sr$ produced. Decay of beta radiation approximated the $T^{-1.2}$ decay expression from H + 12 to H + 6000 hours; decay of gamma radiation deviated to the extent that doses calculated by the observed decay values were 1.8 to 2 times greater than those calculated by the $T^{-1.2}$ relationship. There were also significant differences in the gamma energy spectrum with time after detonation. In the environment, fallout radioactivity was apparently confined to the upper 2 inches of soil unless the soil was mechanically distributed. The majority of the fallout debris which was redistributed by environmental factors on the soil surface after original deposition consisted of less than 44 micron diameter particles; this size particle also represented the predominant contamination on forage plants. Strontium-90 surface soil contamination levels in Nevada and Utah in August 1958, ranged from 32 to 142 $mC/mi^2$ in virgin areas near known fallout pattern midlines and from 7.5 to 28 $mC/mi^2$ in agricultural areas which did not necessarily coincide with fallout pattern midlines. During this Test Series Operation, the level of uptake of $^{132}I$ and $^{131}I$ by native animals was a function of distance from ground zero. $^{140}Ba$, $^{103,106}Ru$, and $^{89,90}Sr$ were major bone contaminants. Milk samples collected from Nevada and Utah farms before, during, and after the Plumbbob Test Series showed that strontium levels increased in milk immediately following contamination of the farm with fallout debris and then decreased with time. Studies clearly indicated that accumulation of radionuclides by mammals cannot be assessed only on the basis of dose rate measurements of the gamma radiation field. Radionuclides from fallout debris are assimilated by animals with the maximum degree of accumulation occurring not necessarily near ground zero. Furthermore, within a distance of 10 to 400 miles from the Nevada Test Site, the plant foliage is a selective collector of small size fallout particles within the less than 44 micron fraction and is the primary source of radionuclides to foraging animals. No significant accumulation of radionuclides through the root system of plants has been observed. Biological availability of fallout debris is strongly influenced by the distribution of fallout contamination and by the physical and chemical nature of the fallout material and its interaction with climatic, biotic, and edaphic factors. The data suggest that the higher levels of $^{90}Sr$ in the indigenous animals are associated with animals that were living in the early sequence of contamination. (auth)

**1462** RADIOACTIVE ISOTOPES FROM FALLOUT IN WASTEWATER. Garry, J. A. (City of Exeter Sewage Works, Eng.); Flack, F. C.; Jakeways, R. J. Water Pollut. Contr. Federation, 37: 871-5(June 1965).

Measurements of fallout radioactivity in sludge samples from the southwestern corner of the United Kingdom show much the same isotope content as do measurements in sludge samples from California. A difference apparently exists between the 2 sets of results concerning the half-lives of some of the isotopes found. The specific activity of primary sedimentation or return activated sludge at the time of this study (1962), was about 100 $\mu\mu$Ci/g and showed a close correlation with rainfall. (auth)

**1463** CALCULATION OF PRECIPITATION SCAVENGING OF PARTICULATES AND GASES FROM THE ATMOSPHERE. Engelmann, R. J. (Pacific Northwest Lab., Richland, Wash.). Nucl. Safety, 7: 354-64(Spring 1966).

A firm basis for calculations of precipitation scavenging of particulates and gases from the atmosphere and a guide to quantitative predictions are presented. Collection efficiencies, washout coefficients for particles and gases, rain spectra, and washout by snow are discussed, and values are given. Extensive area within a washout isopleth charts are shown for three atmospheric stabilities and several washout coefficients. (auth)

**1464** NATURAL RADIOACTIVITY ($^{222}Rn$) AND AIR POLLUTION MEASUREMENTS IN WASHINGTON, D. C. Hosler, Charles R. (Air Resources Lab., Washington, D. C.). J. Appl. Meteorol., 5: 653-62(Oct. 1966).

Atmospheric concentrations of radon ($^{222}Rn$) were measured at urban, suburban, and rural sites in the Washington, D. C., metropolitan area during a stagnant weather regime in mid August 1965. An analysis of air quality data, radon concentrations, and meteorology indicates that the stagnant weather conditions which lead to the accumulation of smoke, haze and gaseous pollutants in the air are conducive to the accumulation of radon in the lower atmosphere. During maximum stagnation radon concentrations were 2 to 4 times higher than normal; the high levels of natural radioactivity reflect the limited volume of air available for dilution, caused by a restriction to vertical mixing that prevailed throughout the stagnant period. This case study suggests that high concentrations of natural radioactivity will be indicative of air pollution potential conditions existing in the atmosphere. Also, air quality data indicated that heavy rains and vigorous mixing associated with a squall line were ineffective in cleansing or displacing, for a significant length of time, the polluted air mass. (auth)

**1465** ATMOSPHERIC OZONE AND RADIOACTIVE FALLOUT. Miyake, Y.; Kanazawa, T. (Meteorological Research Inst., Tokyo). 6p. (CONF-640817-1). PRAU. Gmelin, AED-CONF-64-164-10.

From International Atmospheric Ozone Symposium, Albuquerque, N. Mex.

There is a close correlation between atmospheric ozone and radioactive fallout. Both are of stratospheric origin and show spring maxima and meridional distributions. Ozone is formed photochemically in the upper atmosphere while radioactive debris is injected as cloud mass. Ozone is gaseous and debris is colloidal. Ozone is decomposed in the troposphere by oxidation and debris is scavenged by rain and dust. Maximum fallout appears most frequently in April and May; ozone between January and June. The residence time of the debris in the lower stratosphere is from one to two years with a shorter residence time for ozone. Fallout residence time in the troposphere is from 30 to 40 days, while ozone residence time is less than a month. (F.S.)

**1466** PRESENT STATUS OF FALLOUT IN JAPAN. Katsuragi, Yukio (Meteorological Research Inst., Tokyo). 5p. (CONF-631111-2). ORAU.

From International Symposium on Radioactive Contamination of the Human Environment, Hiroshima.

Data are reviewed on the amounts of fission products resulting from nuclear explosions from 1945 through 1962. It is pointed out that the Soviet nuclear test series of 1961 and 1962 and the U. S. test series near Johnston and Christmas Islands in 1962 were in the upper atmosphere and that most of the explosions were larger than one megaton in size and the resultant fallout was mainly stratospheric. Data are included on the monthly rate of deposition of $^{90}Sr$ at various latitudes in the northern hemisphere during 1962, the monthly deposition of $^{137}Cs$ and $^{90}Sr$ in New York City, Tokyo, and Niigata from 1961 through June 1963, and the average precipitation at these three cities during the same period. Conclusions as to the relationship between meteorological conditions and fallout deposition are presented. (C.H.)

## Mineralogy

*Refer also to abstract 2827.*

**1467** (EFINS-65-102) RARE GAS ISOTOPES IN THE BURSA AND CANNAKALE CHONDRITES. Heymann, Dieter (Chicago Univ., Ill. Enrico Fermi Inst. for Nuclear Studies). Nov. 1965. 6p.

The mass spectrometric analysis of the Turkish Bursa and Cannakale chondrites for helium, neon, and argon is described. Both were found to be typical of ordinary chondrites as far as their rare-gas contents were concerned. The $^{4}He$ and $^{40}Ar$ ages indicate that both meteorites had cooled below 40°C ~$3.5 \times 10^{9}$ yr ago, and have not been reheated to much above this temperature since this time. (F.S.)

**1468** COMPARATIVE INVESTIGATIONS OF THE URANIUM CONTENT OF ZIRCONS WITH PARTICULAR CONSIDERATION TO THEIR MORPHOLOGY. Sansoni, G. Chem. Erde, 25: 1-95 (1966). (In German).

Samples of zircons from various sources were examined: 74 samples from eruptive rocks, 18 from metamorphic rocks, 11 from sedimentary rocks, and 22 from alluvial deposits. They were classified by density, phase analysis, micropanner, magnetic separation, and electric separation. They were ground and dissolved in a carbonate-borate mixture and an aliquot taken for U analysis. The aliquot was extracted with ethyl acetate, which was evaporated on a NaF–LiF tablet for fluorescence analysis. The calibration curve, error determinations, and interference by other elements are discussed. The U content of samples is reported; factors affecting it are state of the zircon, impurities on the crystal surface, isotropizations and strains, trace elements extracted from the zircon, U solubility, post-crystallization processes. The amount of U in a sample and the nature of codeposited rock appear to have no correlation; no correlation was obtained between the age of the deposit and the U content. There is no correlation with the color of the zircon. Correlations are noted for eruptive rocks between U content and type of stone. (BBB)

**1469** MICRODISTRIBUTION OF RADIOACTIVE ELEMENTS IN POTASSIC ALKALINE ROCKS. Mineeva, I. G.; Korobkov, V. I. Geokhimiya, No. 7, 796-804(July 1966). (In Russian).

In a microradiographic study, it was found that the distribution of radioactive atoms in rock-forming minerals obeys the exponential law. In accessory minerals, the distribution was lognormal. In independent U or Th minerals, the distribution of radioactive atoms did not contradict the normal law. (F.S.)

**1470** URANIUM DISTRIBUTION IN THE TOURNAISIAN DEPOSITS OF THE WESTERN PART OF THE ORENBURG PROVINCE. Danchev, V. I.; Kuznetsov, V. G. Geokhimiya, No. 7, 870-3(July 1966). (In Russian).

The distribution and content of uranium and allied elements in the Orenburg district Tournaisian deposits were studied using the core material from holes drilled in 60,000 $km^2$ in the western part of the region. Photometric characteristics of the trans-Volga and Chernyshev deposits are presented in graphic form. The average content of 192 samples taken from the Tournaisian deposits was $6.5 \times 10^{-5}$% or one-third as large as the Russian plateau carbonate deposits. (R.V.J.)

**1471** URANIUM MINERALIZATION IN A SKARN IRON ORE AT HAKANTORP, COUNTY OF OREBRO, SWEDEN. Welin, Eric (Aktiebolaget Atomenergi, Stockholm). Geol. Foren. Stockholm Forh., 83: 129-43(1961).

About 8 miles east of the northern end of Lake Vättern, near Häkantorp in the County of Orebro in Central Sweden, a strongly metamorphosed and folded Archean series of supracrustal rocks contains small skarn iron ores. Uranium mineralization was discovered here in 1951 through an investigation of the radioactivity of old waste dumps. Discovery of radioactivity in waste dumps in another part of the ore field in 1955 led to a careful investigation of the uranium mineralization. Radiometric and magnetic measurements, diamond drillings, and exploratory mining were carried out. Some of the old water-filled mines were also drained. In a few ore bodies uraninite disseminations occur along shear zones. The precipitation of uraninite is caused by the reducing action of the ferrous iron content in tremolite and magnetite on acidic uranium-bearing ore solutions. Geological and mineralogical evidence as well as age determinations indicate that the mineralization is connected with the end of the palingenic phase which concluded the Svecofennian orogeny. The mechanism of uranium mineral formation in this field is discussed. (BBB)

**1472** PITCHBLENDE-BEARING VEIN FILLINGS IN THE STRIPA AND BLANKA IRON ORES. Welin, Eric (Aktiebolaget Atomenergi, Stockholm). Geol. Foren. Stockholm Forh., 86: 257-70(1964).

A description is given of pitchblende-bearing vein fillings discovered in the Stripa and Blanka iron ores in 1956 and 1957 respectively. The vein fillings are distinctly younger than the folding of the iron ores and the intrusion of the late-kinematic Svecofennian granites. The gangue consists of chlorite, quartz, and calcite. Pitchblende is the main ore mineral but hematite, pyrite, chalcopyrite, galena, and bornite occur in lesser amounts. The pitchblende often is partially replaced by a low reflectivity pitchblende occasionally associated with some coffinite. The vein fillings are of the same age (1585 Myr) and paragenetic type as the previously described veins in Uppland, and confirm the conclusions regarding genesis and ore-forming processes of the uranium mineralization in Central Sweden previously made by the author. The spatial connection between the pitchblende-bearing fractures and the iron ore is discussed. The paragenesis and tectonics of the vein fillings in Stripa and Blanka mines point to a chemical relation between the uranium mineralization and the iron ores. Thus, the uranium-bearing solutions could flow through the brittle, easily fractured ore in larger amounts than through the surrounding less competent rocks. (BBB)

## Oceanography

*Refer to abstract 1539.*

## Seismology

*Refer also to abstracts 1478 and 2826.*

**1473** (AD-632453) RESEARCH IN SEISMOLOGY. (Air Force Office of Scientific Research, Washington, D. C.). 1965. 92p. (AFOSR-65-2667). CFSTI $3.00 cy, $0.75 mn.

A program of basic research in seismology was carried out to improve the capability to distinguish seismically between nuclear explosions and natural geological events. Research efforts were applied in areas of identification techniques, data processing, array configuration, deep-hole and ocean bottom detection, instrumentation techniques, magnitude-energy scale relations, noise studies, earth seismicity, explosion and earthquake source mechanism studies, crustal studies, and theoretical studies. Summaries of accomplishments in these efforts are presented. (TAB)

**1474** SEISMIC CRUSTAL FUNCTION OF THE EARTH. Shimshoni, M.; Pekeris, C. L. (Weizmann Inst. of Science, Rehovoth, Israel). Geophys. J., 11: 1-4(Sept. 1966).

Assuming a spherically symmetrical earth, usual travel time tables are functions of distance only. It is well known that this assumption is not strictly correct, and that local corrections to the times are needed. Such corrections are dependent on the location of both the epicenter and the recording station. An attempt is made to express these corrections for P waves in a mathematical form as an expansion in functions which are symmetrical with respect to the source and the observing station. Data used to date come from recordings of nuclear explosions, and results obtained are promising. The correction function obtained should chiefly depend on the constitution of the crust, and one might be able to deduce large-scale crustal variations from it. (auth)

# ENGINEERING

## Nuclear Explosions

*Refer also to abstracts 1460, 1466, and 2827.*

**1475** (AD-631105) LONG RANGE SEISMIC MEASUREMENTS: YUBA. Clark, Don M. (Teledyne Industries, Inc., Alexandria, Va. Earth Sciences Div.). Mar. 17, 1966. Contract AF 33(657)-15919. 30p. (SDL-140). CFSTI $2.60 cy, $0.50 mn.

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves are included along with other unidentified phases. (TAB)

**1476** (AD-634674) THEORY OF SHOCK INTERACTIONS FOR MULTIPLE UNDERGROUND NUCLEAR EXPLOSIONS AND THE RESULTING HYPOTHETICAL CRATER VOLUMES. Eaton III, Russell (Army Engineer Research and Development Labs., Fort Belvoir, Va.). [1965]. 9p. CFSTI $1.10 fs, $0.80 mn.

A cratering theory for single and multiple explosions was developed. Using computer codes based on cratering and Porzel theories, cratering curves for single explosions of yields of 10 Kt were computed. Using available data the theory is well supported. The lowering and shifting of the optimum depth of burst to lower scaled depths is supported by the results of a large number of high explosive (TNT) cratering tests. The effect of non-simultaneity of detonation times has also been computed; these computations show that the crater volume decreases with increasing time lags. Code originally written for wet tuff are being generalized to handle all soil materials. To handle large explosives, the effects of the actual expansion path and the actual motion of the cavity are incorporated in the codes. (F.S.)

**1477** (AWRE-O-67/66) SOME SEISMIC RESULTS OF THE LONG SHOT EXPLOSION. Marshall, P. D.; Carpenter, E. W.; Douglas, A.; Young, J. B. (Atomic Weapons Research Establishment, Aldermaston (England)). Oct. 1966. 15p. Dep. mn. BIS $0.50. HMSO 2s. 6d.

LONG SHOT, with a predicted yield of 80 Kt, was detonated underground on Amchitka Island in the Aleutians and recorded at Eskdalemuir, Yellowknife (Canada), Gauribidanur (India) and Tennant Creek (Australia). The results of processing of the array records are presented and compared with the results from many other stations. The location of the epicenter is also discussed. (auth)

**1478** (NP-15686) THE DETECTION AND RECOGNITION OF UNDERGROUND EXPLOSIONS. A Special Report of the United Kingdom Atomic Energy Authority. (Atomic Weapons Research Establishment, Aldermaston (England)). Nov. 1965. 52p. Dep. mn.

Progress made in detecting nuclear explosions by seismological techniques is summarized. The development of new instruments and instrument arrays and the use of modern data techniques have led to a different concept for a monitoring network. Fewer stations are now thought to be required for a world wide system. Stations a few thousand miles from the event can now play a vital part in detecting and identifying an event. Basic problems, difficulties encountered, and future objectives of the program are described. (F.S.)

**1479** (PNE-710F) SCIENTIFIC PHOTOGRAPHY. Project SULKY. Final Report. Brower, R.; Wilson, D. (Edgerton, Germeshausen and Grier, Inc., Las Vegas, Nev.). Aug. 25, 1965. Contract AT(29-1)-1183. 125p. Dep. mn. CFSTI $2.00 cy, $0.75 mn.

Sulky, a Plowshare experiment, was detonated 1135 hours, December 18, 1964, on Buckboard Mesa, Nevada Test Site. The Sulky explosive was a 90 ton nuclear device buried to a depth of 90 feet in basalt. Scientific photography designed to measure ground surface motions, base surge growth, and cloud evolution is described. The Sulky technical photographic instrumentation systems performed as programmed. Mission objectives were met; data were obtained from which quantitative measure of surface motion, base surge and cloud phenomena could be made. (auth)

**1480** (PNE-713F) CRATER MEASUREMENTS. Project SULKY. Videon, F. F. (Army Engineer Nuclear Cratering Group, Livermore, Calif. California Univ., Livermore. Lawrence Radiation Lab.). Oct. 1965. Contract W-7405-eng-48. 37p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Project Sulky was the detonation of an 85-ton nuclear device in basalt at a depth of burst of 27.4 meters. The detonation produced a mound of broken rock with a depression in the center. The base of the mound was roughly circular in plan and had a radius of 24.2 meters. The radius of the crest of the lip around the ejecta was 8.87 meters and the average height of the lip crest above preshot ground surface was 6.31 meters. The bottom of the depression was 2.80 meters above the preshot ground elevation. The preshot ground surface was uplifted and cracked to a distance of approximately 52 meters from surface zero. The height of the upthrust was 1 meter at the base of the rubble mound. Based on the results of Sulky and other cratering data for basalt, the following conclusions have been made concerning cratering in hard, dry, inert rock: (1) In the region of depths of burst somewhat deeper than optimum, nuclear explosives are less effective than high explosives for apparent crater production. (2) Apparent crater dimensions diminish rapidly as the depth of burst increases beyond optimum. (3) The apparent lip height, the true crater radii and the extent of upthrust beyond the true crater are similar for both nuclear and high explosive craters in basalt. (auth)

**1481** (PNE-904) PROJECT PALANQUIN: STUDIES OF THE APPARENT CRATER. Final Report. Videon, Fred F. (Army Engineer Nuclear Cratering Group, Livermore, Calif.). Apr. 1966. Contract W-7405-eng-48. 34p. Dep. mn. CFSTI $1.50 cy, $0.50 mn.

Project Palanquin was a low yield nuclear detonation conducted by the Lawrence Radiation Laboratory as a part of the AEC Plowshare Program. The device was detonated in a porphyritic trachyte flow of the Ribbon Cliff Rhyolite formation, a hard dry rock, at a scaled depth of burst of 55.6 meters/$kt^{3.4}$. Since the depth of burst was deeper than that which results in maximum apparent crater dimensions in rock, it was predicted that the detonation would result in a rubble mound rather than a crater below ground surface. Detonation of the Palanquin device produced an apparent crater 72.6 meters in diameter and 24.0 meters deep. The production of an apparent crater was probably the result of scour by the escaping gas which vented prematurely. The asymmetry of the crater and the surrounding disturbance of the ground surface indicate the influence of geology in producing the crater. The crater is nearly hyperbolic in cross section, and the maximum inclination of the slopes of the crater walls is about 35 degrees. The lip of the Palanquin crater resulted primarily from an upward displacement of the original ground surface. The distance to the edge of this uplifted zone is about twice the depth of burst. This extent of uplift agrees well with the results of the Sulky detonation (device detonated at scaled depth of 56.5 meters/$kt^{3.4}$). The magnitude of the vertical displacement of the lip of the Palanquin crater, however, was less than that for Sulky. (auth)

**1482** (TID-23389) DETERMINATION OF THE HUGONIOT EQUATION OF STATE OF GROUT. REPORT I. 1963 TESTS. Sugiuchi, Howard (Army Engineer Waterways Experiment Station, Vicksburg, Miss.). Jan. 1965. Contract AT(29-2)-752. 30p. (TR-6-669). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The emplacement of instruments in the hydrodynamic shock range of a nuclear detonation has necessitated the study of the shock characteristics of the emplacing grouts. If the Hugoniot equation of state of the grout does not match that of the surrounding medium, a mismatch will occur at the interface of the grout and surrounding medium, causing a distortion of the shock front. The Hugoniot equation of state is determined by the locus of pressure–volume points generated by shocks from a given state. Plane wave lenses were employed to produce plane shocks in the range of 100 to 300 kilobars in the grout specimens. Shock–arrival indicators (metal pins connected to oscilloscopes) were placed in the specimen and above a free surface to measure shock–wave and free–surface velocities from which the pressure and specific volume were computed by means of the Rankine–Hugoniot equations. The first grouts tested were hydrating cement grouts, using portland or calcium–aluminate cement; they were intended to match the shock impedance of rock salt. The impedances determined, especially those for shocks in the region of 300 kilobars, were too low to be considered matches. In addition, it appears that the free–surface velocity of these grouts cannot be measured reliably by means of the pin–contactor method used in this investigation. Because of what appeared to be a low shock impedance of the hydrating cements, an epoxy–resin grout was proportioned. Two pressure–volume points were determined for this grout which showed this mixture to have a higher impedance than rock salt. Therefore, a match could be achieved by replacing some of the aggregate with a material having a lower shock impedance. This

approach may offer a means of achieving shock–impedance matches of grouts with natural materials. (auth)

**1483** (VUF-3016) VENT-GAS TREATMENT PLANT. Project DRIBBLE: SALMON EVENT. Final Report. Snoeberger, D.; Heckman, R. (eds.) (Lawrence Radiation Lab., Univ. of California, Livermore). Mar. 1966. Contract W-7405-eng-48. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A vent gas treatment plant was designed for the Project Dribble Nuclear detonation in the Tatum Salt Dome near Hattiesburg, Mississippi. The process consists of a remotely operated gas scrubbing and filtering system with charcoal adsorption units incorporated with the filters. The system will take up to 200 $ft^3$/min of cavity gas mixed with 2,000 $ft^3$/min of air to dilute H. Effluent gas is discharged from a 150-ft stack after being mixed with 20,000 cfm of additional air. Liquid wastes from the scrubbers are stored in four 25,000-gal tanks for later disposal. (F.S.)

**1484** (AEC-tr-6777) UNDERGROUND NUCLEAR EXPLOSIONS. PROBLEMS OF INDUSTRIAL NUCLEAR EXPLOSIONS. Nifontov, B. I.; Protopopov, D. D.; Sitnikov, I. E.; Kulikov, A. V. Translation of Podzemnye Yadernye Vzryvy. Problemy Promyshlennykh Yadernykh Vzryvov, Atomizdat, Moscow, 1965. 189p. (PNE-3004). Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Industrial uses of underground nuclear explosions are reviewed. These uses include the construction of large civil engineering structures, mineral mining, extraction of petroleum from oil shales, generation of electrical power, and other scientific and technological uses. Also discussed are the optimum conditions under which underground nuclear explosives are detonated, internal and external effects, and seismic and air compression effects. The Gnome and Sedan experiments are also reviewed. (R.C.K.)

**1485** SHOCK: A PROCESS IN EXTRATERRESTRIAL SEDIMENTOLOGY. Roberts, Wayne A. (Boeing Co., Seattle). Icarus, 5: 459-77(Sept. 1966).

Impact-induced shock is an operative process on planetary surfaces and provides the mechanism for comminution, transport by ballistic ejection, and deposition in regions adjacent to the shock focus. Shock is produced by impingement of particles or fragments, regardless of size, traveling at hypersonic velocities relative to the target. Formation of shock craters affects a volume of material several orders of magnitude larger than the missile. Degree of comminution of the ejected volume, and, generally, velocities and angles with the horizontal should decrease radially outward from the shock origin. Deposits of ejecta thin radially outward with a probable general decrease in median grain size with increasing radial distance from the crater and upward from the base of the ejecta deposit. Some of the ejected material travels outward with densities high enough, or porosity low enough, that winnowing action by an atmosphere does not occur. Other material, generally that ejected at higher velocities and angles, is winnowed and sorted by the atmosphere during ballistic flight. Fallback in the crater is composed of this latter material as well as material from the rim which slides back into the crater depths. Range of ejecta deposits is a function of ejection angles and velocities, gravity, and drag by the atmosphere. Ballistic range of ejectamenta can be extreme where no atmosphere is present and gravity is low. Where an atmosphere is present, fine material suspended or settling slowly can also be transported large distances by winds. The unwinnowed material, called bulk ejecta, is deposited in an order the inverse of the preshock vertical sequence. (auth)

## Facilities and Equipment

*Refer also to abstracts 1549, 1893, and 2134.*

**1486** (AD-637458) FACILITIES FOR HIGH-INTENSITY NEUTRON IRRADIATION. Marion, Jerry B. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Jan. 1966. Contract DA-49-146-XZ-230. 59p. (AFRRI-CR-66-4). CFSTI $3.00 cy, $0.75 mn.

Studies of neutron-producing facilities which may be suitable for the investigation of neutron effects in biological material are described. An analysis of the possibilities of producing high-intensity beams of neutrons with energies other than 14 MeV is presented. It appears that the 3-MV accelerators which are likely to be available within the next few years will be capable of delivering beams of charged particles with currents up to about 15 mA. With this beam limitation it will not be possible to deliver a sample irradiation flux of more than $10^{11}$ n/sec, if monoenergetic neutrons ($\Delta E \cong 10\%$) are required. On the other hand, present capabilities of higher energy accelerators (e.g., 100-MeV cyclotrons) will permit the generation of $\sim 10^{15}$ n/sec. Since the majority of these neutrons are emitted into a very narrow forward cone, it would be possible to utilize almost the entire neutron output for irradiation purposes. For biological studies in which the maximum possible neutron flux is required, it appears that an accelerator which will yield beam energies considerably in excess of 3 MeV will be required. (auth)

**1487** (AERE-R-5184) EVALUATION OF AIRHOODS AND AIRBLOUSES USED AT A.E.R.E. Stevens, D. C.; Ritchie, J. B. (Atomic Energy Research Establishment, Harwell (England)). Sept. 1966. 17p. Dep. mn. BIS $0.70. HMSO 3s. 6d.

The penetration of a NaCl aerosol into airhoods and airblouses has been measured at various flow rates of compressed air. A flow of 5 cfm is required to insure a protection factor of 1000 (penetration <0.1%). A direct reading prototype flow meter has been made which can be permanently inserted into the airline near the hood or blouse so that a wearer can adjust his air flow as required, above a recommended minimum value. Measurements are also reported on the noise levels in airhoods and blouses and simple means of reducing these have been investigated. At a flow rate of 5 cfm, the noise level in the hoods and blouses in use at A.E.R.E. is about 90 db and users could experience discomfort and possible temporary (hearing) threshold shift. However, these noise levels can be reduced by as much as 15 db by the insertion of simple filter pads at the air inlet. New designs of hoods and blouses are provided with sound baffle filters and in these, the noise levels are satisfactory. (auth)

**1488** (ORNL-TM-1627) OROSEF: A FORTRAN CODE FOR OVERALL DESIGN OF THE MULTI-STAGE FLASH DESALINATION PLANT. Mothershed, C. T. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 80p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A Fortran IV code was written to design a multi-stage flash desalination plant consisting of a brine heater which receives heat from an external source and transfers it to the brine, an evaporator recovery section which produces the major part of the product water and recovers heat to permit the plant to operate at performance ratios greater than one, and the evaporator reject system which rejects the heat to the coolant while producing a minor portion of the total product water. The code is used to calculate process flows and temperatures, heat transfer coefficients, plant geometry, and water cost. (F.S.)

**1489** (ORNL-TM-1634) COMPARISON OF THEORETICAL AND EXPERIMENTAL STRESSES ON A SPHERICAL SHELL WITH A SINGLE RADIALLY ATTACHED NOZZLE. Witt, F. J.; Gwaltney, R. C.; Greenstreet, B. L. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 41p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The stresses on a series of steel spherical–shell models with single nozzles radially attached were examined with strain gages. The parameters studied were nozzle dimensions and length of internal nozzle protrusions. The loads were internal pressure on the shell and nozzle and axial thrust and moment loadings on the nozzle. Both experimental and theoretical stresses are reported for six configurations for which the sphere dimensions were equal and the outside diameter of the attached nozzle was constant. In most instances the nozzle protruded through the vessel. Empirical design data were obtained and the adequacy of theoretical methods assessed. The most significant conclusion is that for each configuration and all loadings the maximum experimental stresses are well approximated by the theoretical analyses. The approximations improved for the thinner nozzles. The theoretical stress distributions also agreed quite well in general with those obtained experimentally. (auth)

**1490** (UCRL-14705) WATER-WASHED EXHAUST VENTILATION SYSTEM FOR HOT CELLS. Stearns, Edward (Lawrence Radiation Lab., Univ. of California, Livermore). Feb. 7, 1966. Contract W-7405-eng-48. 5p. (CONF-661001-25). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 14th Conference on Remote Systems and Technology, Pittburgh, Pa.

Many problems are associated with the use of roughing or high-efficiency filters within a hot cell. Among these problems are: buildup of atmospheric dust which causes a high pressure drop across the filters, susceptibility of filters to chemicals, destruction of filters by fire, plugging of filters by smoke particles in the event of fire, disposal problem due to high radioactivity of the filters. To alleviate roughing problems of high efficiency filters, a system which exhausts directly from the cells via a shielded trench to an air-cleaning system in an adjacent building was adopted. The air cleaning system is composed of two parallel systems, each consisting of a 5000-cfm spray-type centrifugal scrubbing tower and a bank of high-efficiency filters. The tower, which operates at 120 psi, includes demisters and heat coils to reduce the relative humid-

ity enough so that water cannot accumulate on the high-efficiency filters. The wash water is recirculated at 17 gal/min per system through 5-$\mu$ fiber cartridge-type filters and mixed bed ion-exchange columns. The filters and exchange columns are cast in disposable concrete shielding blocks to minimize radiation exposure. High concentrations of rock dust, hydrofluoric acid, and other aerosols have been released to the system. In addition, a petroleum fire occurred directly in front of one of the exhaust ducts and burned for about 15 minutes. In spite of these problems the scrubbing towers have been so effective that the high-efficiency filters installed in August of 1962 are still in operation in January 1966. (auth)

**1491** (UCRL-14849) A DOWNDRAFT TABLE FOR HANDLING HIGH RADIOTOXICITY ALPHA EMITTERS. Denham, Dale H.; Curtis, J. Richard (Lawrence Radiation Lab., Univ. of California, Livermore). July 12, 1966. Contract W-7405-eng-48. 16p. (CONF-661001-8). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

For Presentation at 14th Conference on Remote Systems Technology, Pittsburgh, Pa.

A downdraft table housed in a specially constructed stainless steel room is used for open-air operations on high radiotoxicity alpha-emitting materials. The facility permits the precise manipulation of plutonium-bearing parts with as few restrictions as possible. Contamination is controlled by the high-velocity air stream that passes down over the exposed material and through the downdraft table. Several types of operations have been performed using this facility without the restrictions normally associated with hoods or glove boxes. A description of the facility and its operational history is presented. (auth)

**1492** HYDRAULIC PRESS FOR COMPRESSING RADIOACTIVE WASTE. van Bree, G. N. Th.; Hoving, R.; van Beek, A. M. K. (Stichting Technische en Fysische Dienst voor de Landbouw, Wageningen, Netherlands). Ingenieur (Utrecht), 78: No. 23, G14-16(June 10, 1966). (In Dutch).

The design and the construction of a hydraulic press for compressing radioactive waste in the form of tablets is described. Radioactive waste in this form may be handled more safely, while in temporary storage. The transportation of the tablets to centralized waste storage areas elsewhere can also be done more economically. To avoid contamination of the laboratory the interior of the cabinet for the press is kept continuously just below atmospheric pressure by means of an air purification unit. Glove ports give access to the inside of the cabinet. (auth)

**1493** DESIGN OF LABORATORY BUILDINGS FOR WORKING WITH RADIOACTIVE SUBSTANCES. Shchukin, V. P. Sb. Tr. Mosk. Inzh.-Stroitel. Inst., 41: 45-63(1962). (In Russian).

The problems facing the architect-engineer who designs buildings for handling highly radioactive materials while protecting the workers against radiation injury, are reviewed. Both research laboratories and pilot plants are considered. The cases that must be taken into account include protection against ionizing radiation, radioactive contamination, and the combination of these two cases. In addition to the protection of personnel, shielding must be provided for some of the more sensitive instruments. Actual design of the building depends on the health-physics regulations in force, the branch of science to be served and the intended function of the building, such as research, education, etc., and the equipment to be installed. In structural calculations, the required shielding materials, such as heavy concrete, special metals, etc., must be taken into consideration. Whether a hot laboratory should be placed in an isolated portion of a building or be made into a separate building depends on other factors, including convenience of operation and construction costs. Floor plans and elevations of various existing hot-cell blocks and canyons are presented, pointing out the advantages and the shortcomings of specific solutions. (TTT)

**1494** OPERATION OF THE EXPERIMENTAL MEASURING SYSTEM OZH-1 AND OZH-2 FOR NUCLEAR REACTORS. [PART] II. Bollok, Lajos; Mathe, Ivan Gyoergy; Selley, Gabor (State Inst. of Research in Physics, Budapest). Energ. Atomtech., 19: 78-83 (Jan.-Feb. 1966). (In Hungarian).

The following systems of the OZH-1 and OZH-2 measuring devices for nuclear reactors have been tested in operation: organic liquid system, pressure control, gas flow measurement, sampling, coolant water system, ventilation, low-pressure heat-insulating gas system and the leak detection and elimination system. The control systems worked satisfactorily with both loops; the safety circuits were automatically triggered by faults in the subsystems. No breakdowns attributable to malfunctioning of the control system were experienced in the loop experiments. The operational parameters were recorded by instruments on the control board where sound and light alarms warned the operator about unusual conditions. The temperature was measured by resistance thermometers, the cold junction of which was kept at 53°C. Dual sensors were installed at critical points in order to prevent overheating that could result in the formation of holes in the jacket. (TTT)

**1495** RADIATION-PROTECTED UNDERGROUND WATER WORKS OF THE KIEL MUNICIPAL WORKS. Siebel, H. (Stadwerke Kiel AG, Kiel). Neue Deliwa-Z., 2: 51(Feb. 1964). (In German)

The recently constructed water works with a protection level of S.0.3, built in a forest along the road to the Holtenauer Hochbruecke is described. Total cost was DM 2,600,000, not including the cost of the water conduits. The hourly power for the new works produces 800 $m^3$ water, increasing the total production for the city to 85,000 $m^3$ on a hot day, an increase of 20%. The construction is a cubic bunker with a large area for the pumping equipment and aeration and filtration for removal of $CO_2$ and Fe. Underwater pumps carry the water to an aeration area. Between the filtering station and pure water pumps a large reservoir is located beneath the machine area. The pure water pumps located here remove the water and introduce it into the city network through new conduits of up to 600 mm dia. Automatic emergency current is provided by diesel motors to supply the works with the proper flow. The coarse sand filter for aeration retains radioactive materials from the air used in aeration. The plant may be closed off from the outside for periods of weeks. (BBB)

**1496** IMPROVEMENTS IN OR RELATING TO MULTISTAGE EVAPORATORS. Starmer, Roy (to Richardsons, Westgarth and Co. Ltd.). British Patent 1,047,981. Nov. 9, 1966. Filed Nov. 8, 1961.

A multi-stage flash evaporator is described which consists of a series of stages each having a flash chamber, and a heater-condenser chamber wherein vapor generated in the flash chamber is brought into indirect heat exchange with the liquid to be evaporated to which it gives its latent heat and is condensed. The feed brine is preheated by being passed through a series of heaters in the heater-condenser chambers. It is heated further by live steam from an external source. The evaporator may be used for impure or sea water. If high pressure steam is not available, the evaporator may be run on low grade waste steam. (F.S.)

**1497** ANTI-SHOCK DEVICE FOR A PRESSURE VESSEL. Ukaji, Hideo (to Hitachi Ltd.). Japanese Patent 1965-29415. Oct. 13, 1965. Filed Nov. 24, 1962.

This proposed device protects a pressure vessel from shock and prevents expansion distortion due to temperature and pressure changes. Support rods with pistons in their tops are installed around the pressure vessel. Other rods connecting to the first set of rods through the cylinders for the pistons are distributed circumferentially on the outside surface of the pressure vessel, safely supporting the pressure vessel. (TSS)

**1498** IMPROVEMENTS IN AND RELATING TO HEAT EXCHANGERS. (to Sulzer Brothers Ltd.). British Patent 1,048,567. Nov. 16, 1966. Priority date Oct. 9, 1962, Switzerland.

A heat exchanger is described in which the heat exchange elements are contained in a circular cross-section exchanger. Each element is bounded laterally by parallel planes, the spacing between the planes is less than the other external dimensions of the elements. The elements are positioned in arcuate layers within sectors of the circular cross-section with the boundary planes of adjacent elements in each layer parallel and adjacent to each other. All elements are of substantially identical dimensions. The arcuate layers of a sector all have the same radius of curvature. The heat exchanger is used in transferring the heat of a heat carrier flowing through a reactor to the working fluid of the power plant. (F.S.)

**1499** SUPPORT FOR A HIGH-TEMPERATURE AND HIGH-PRESSURE VESSEL. Hamada, Kunio; Oguchi, Isao (to Hitachi Ltd.). Japanese Patent 1965-29727. Oct. 18, 1965. Filed Nov. 10, 1961.

An improved support is described for firmly holding a high-temperature and high-pressure vessel, e.g., a nuclear reactor to the ground. The heat-insulating material, which surrounds the pressure vessel extends downwards to a point in the middle of the support body to which the downward expansion of the vessel is permissible. The inside of the support body is lined with heat-insulating material. Another insulating material is installed below the pressure vessel. (NSA of Japan)

## Heat Transfer and Fluid Flow

*Refer also to abstracts 2828 and 2868.*

**1500** (ALO-3633-2) DEVELOP 1800F-400F FIBROUS-TYPE INSULATION FOR RADIOISOTOPE POWER SYSTEMS. Quarterly

Progress Report No. 2, July 1–September 30, 1966. Collins, J. O. (Johns-Manville Research and Engineering Center, Manville, N. J.). Oct. 3, 1966. Contract AT(30-1)-3633. 44p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Eleven experimental MIN-K formulations were investigated for processing technique, strength and moldability. Two formulations have been tentatively chosen as suitable for 1400°F continuous service, one for bulk insulation application with good strength characteristics, and one for intricate T/E module application. The equipment required for compression–deflection tests, outgassing and compatibility tests, and thermal conductivity measurements are presented, and the results of their initial startups are discussed. (auth)

**1501** (ANL-7184) EFFECT OF THE PRESSURE-TEMPERATURE HISTORY UPON INCIPIENT-BOILING SUPERHEATS IN LIQUID METALS. Holtz, Robert E. (Argonne National Lab., Ill.). June 1966. Contract W-31-109-eng-38. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The degrees of liquid superheat required to initiate boiling in the alkali metals are found by examining the pressure–temperature history of the system and by using the bubble–equilibrium equation. The calculated incipient–boiling superheats for sodium and potassium are shown to be in agreement with data presented in the literature. (auth)

**1502** (CEA-R-3049(Pt. 1)) THE OSCILLATORY BEHAVIOR OF HEATED CHANNELS: AN ANALYSIS OF THE DENSITY EFFECT. PART I. THE MECHANISM (NON LINEAR ANALYSIS). Boure, Jean (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Sept. 1966. 40p. Dep. mn.

The problem of the oscillatory behavior of heated channels is presented in terms of delay-times and a density effect model is proposed to explain the behavior. The density effect is the consequence of the physical relationship between enthalpy and density of the fluid. Non-linear equations are derived from the model in a dimensionless form. A description of the mechanism of oscillations is given, based on the analysis of the equations. An inventory of the governing parameters is established. At this point of the study, some facts in agreement with the experiments can be pointed out. (auth)

**1503** (CEA-R-3049(Pt. 2)) THE OSCILLATORY BEHAVIOR OF HEATED CHANNELS: AN ANALYSIS OF THE DENSITY EFFECT. PART II. THE OSCILLATIONS THRESHOLDS (LINEARIZED ANALYSIS). Boure, Jean (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Sept. 1966. 39p. Dep. mn.

The start of the oscillatory behavior of heated channels is studied in terms of the density effect, a consequence of the physical relationship between enthalpy and density of the fluid. The threshold equations are derived, after linearization of the equations obtained in Part I. They can be solved rigorously by numerical methods to yield: (1.) a relation between the describing parameters at the onset of oscillations, and (2.) the frequency of the oscillations. By comparing the results predicted by the model to the experimental behavior of actual systems, the density effect is very often shown to be the actual cause of oscillatory behaviors. (auth)

**1504** (DP-1024) HEAT TRANSFER STUDIES FOR THE $D_2O$ POWER REACTOR PROGRAM. A Terminal Status Report of the Work at Columbia University. Neill, John S. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Aug. 1966. Contract AT(07-2)-1. 79p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Experiments relating to the heat transfer capability of fuel assemblies for a nuclear power reactor were conducted at the Heat Transfer Research Facility of Columbia University. The heat flux at burnout with forced flow of subcooled and boiling water at high pressure was measured for several types of assemblies: multirod bundles in a circular housing, tubular channels, internally heated annuli, tubes-in-parallel, and tubes cooled on both the inner and outer surfaces. The relation of the particular tests to the development program for a heavy-water-moderated power reactor is discussed. The results, together with the recent results from other laboratories, are applied to a nested-tube-assembly design for a $D_2O$-cooled power reactor. Areas for further investigation are pointed out. (auth)

**1505** (EUR-3113.e) FORCED CONVECTION BURNOUT AND HYDRODYNAMIC INSTABILITY EXPERIMENTS FOR WATER AT HIGH PRESSURE. PART III. COMPARISON BETWEEN EXPERIMENTAL BURNOUT DATA AND THEORETICAL PREDICTION FOR UNIFORM AND NON-UNIFORM HEAT FLUX DISTRIBUTION. Previti, G.; Grillo, P. (FIAT, Turin (Italy). Sezione Energia Nucleare); Campanile, A.; Galimi, G.; Goffi, M. (Societa Ricerche Impianti Nucleari Saluggia (Italy). Centro Ricerche Nucleari). 1966. 138p. Dep. mn.

The increase of power output from a pressurized water reactor core with constant hot channel factor depends largely upon a more accurate prediction of DNB conditions (Departure from Nuclear Boiling). The purpose of the present work is to compare the experimental data obtained for conditions peculiar to small PWR cores with the predictions of several correlations. The experimental data have been obtained from a research program supplementing the design study of a nuclear tanker. The experiments have been carried out by SORIN Heat Transfer Laboratory. The data cover both uniform and non-uniform power distributions as well as unheated wall effect. Although a large fraction of the collected data have been obtained for the tanker reactor design conditions, a certain number of parameters such as pressure, mass flow rate, inlet enthalpy, and diameter have been investigated. (D.L.C.)

**1506** (EURAEC-1514) HEAT TRANSFER AND FLUID FLOW CHARACTERISTICS IN A PRESSURIZED WATER REACTOR. Quarterly Progress Report No. 6, April 1–July 1, 1965. (Technische Hogeschool, Eindhoven (Netherlands)). Contract 011-64-1 Teen (R.D.). 23p. (WW-015-R-89; EUR-2666). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

Experiments have been carried out on a single-rod square annulus geometry for determining the influence of a cold wall and mixing between the fuel channel and a surrounding channel on the burnout power. Some difficulties have been encountered due to the use of a CONAX-connector at the bottom side of the heating element and a wrong type of burnout detector wire. Some data are given which demonstrate very good reproducibility. A program has been set up for performing experiments in an air–water loop and in the 140-atmospheres pressurized loop on a two-channel geometry by making mass and heat balances in two adjacent channels. The air–water loop will be available in the next quarter and experiments can start immediately. The theoretical study on the hydraulic coupling of parallel channels is being continued. (auth)

**1507** (JAERI-1111) METHOD FOR MEASURING VOID FRACTION BY ELECTROMAGNETIC FLOWMETERS. Hori, Masao; Kobori, Tetsuo; Ouchi, Yoshihiro (Japan Atomic Energy Research Inst., Tokyo). Aug. 1966. 35p. Dep. mn.

An electromagnetic void meter, developed for studies of gas-liquid two-phase flows is described. Calibration experiments have been completed, using argon–mercury and air–water two-phase flows through a pipe. The results show that this method can be used for two-phase flows with a non-oscillatory flow pattern (bubble flow) without calibration, and with calibration for the oscillatory flow pattern (slug flow). This method may be applicable to two-phase flows in more complex shaped channels and in boiling conditions. (auth)

**1508** (NAA-SR-12004) FREE CONVECTION OF A SODIUM–POTASSIUM EUTECTIC IN AN ENCLOSED SPACE BETWEEN TWO VERTICAL PLATES WITH UNIFORM HEAT FLUX. Lillie, A. F. (Atomics International, Canoga Park, Calif.). Oct. 25, 1966. Contract AT(11-1)-Gen-8. 77p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

An experimental investigation was conducted of laminar steady–state free convection in an enclosed space between parallel vertical walls with uniform heat flux. Major interest centered on the use of sodium–potassium eutectic (NaK) liquid metal heat transfer medium. Helium and an oil-like fluid (HB-40) were also employed to provide validation of the NaK results. Heat fluxes of 9,660 to 45,500 Btu/hr-$ft^2$ were achieved in the NaK runs. Longitudinal temperature profiles were measured for both the hot and cold heat transfer plates using stainless steel sheathed chromel–alumel type thermocouples. The applied heat flux and the separation distance between the plates were experimental variables. The experimental results indicate that the Kraussold plot, which is a measure of the influence of free convection on the heat flow across plane fluid layers, is valid for liquid metals. From a design standpoint, the Kraussold plot is inconvenient for the case of uniform heat flux since it was devised for the isothermal wall condition. For this reason, a modified Kraussold plot was generated from the data obtained. The modified plot uses those terms known by the designer when starting a calculation to determine the influence of free convection on the net heat flow across plane fluid layers under uniform heat flux conditions. As a first approximation, the modified plot could be extended to other geometries and fluid layer orientations. Qualitative observations made during the course of the investigation showed the existence of an instability situation when conditions of the plate spacings and impressed heat fluxes were appropriate. The instability, postulated to be the result of small

convection vortex cells, causes erratic temperature readings but does not appear to grossly affect the net heat transfer characteristics of the system. The experimental results were compared to the analytical predictions determined from the theory as given by Sparrow and Gregg for laminar steady-state free convection on a vertical wall with uniform heat flux. The results indicate that the local heat transfer coefficients agreed within ±30% even though a basic boundary condition used in the theory was violated. On the cold plate, where the uniform heat flux condition was not met, the agreement was less satisfactory (±50%). Average heat transfer coefficients agreed within ±20% for the uniform heat flux condition. (auth)

**1509** (NYO-3304-9) INVESTIGATION OF BOILING FLOW REGIMES AND CRITICAL HEAT FLUX. Report No. 663. Quarterly Progress Report, December 16, 1965–July 31, 1966. Bergles, A. E.; Roos, J. P.; Bourne, J. G. (Dynatech Corp., Cambridge, Mass.). Sept. 15, 1966. Contract AT(30-1)-3304. 19p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The general construction and operation details of a steam system for the investigation of boiling flow and critical heat flux are described. The steam system, which is incorporated in the water system, pumps steam from the top of the surge and separator tank. The main flow goes through a superheater and a venturi before entering the mixer. A steam loop was added to increase capacity. The loop joins the pump exit and the surge tank. Spray cooling controls the superheat of the bypass flow. With the loop, it is possible to obtain high exit qualities in large-dia tubes with the limited test-section power that is available. (F.S.)

**1510** (RT-ING-(66)-1) ITERATIVE METHODS FOR THE ANALOG SIMULATION OF PHYSICAL SYSTEMS CONTAINING FLOWING FLUIDS. Mathis, A.; Giordano, P.; Gatto, G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1966. 26p. (CONF-650505-6). Dep. mn.

From IFIP Congress 1965 Meeting, New York.

Several means of solving by iterative analog computation, the partial differential equations describing systems containing flowing fluids are evaluated. The discretization of space and time variables by central and backward differences, are compared, with respect either to their possibilities in the simulation of physical systems, or to the errors involved. (auth)

**1511** (RT-ING-(66)-3) EBOLLIZIONE IN CONVEZIONE LIBERA. RAPPORTO DI AVANZAMENTO AL 30 SETTEMBRE 1965. (Boiling Heat Transfer. Report of Advances up to September 1965). Cumo, M.; Farello, G.; Pinchera, G. C. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1966. 79p. Dep. mn.

A pool boiling experiment is described, concerning boiling mechanism and critical heat flux with water and carbon tetrachloride. Effects of heater characteristics, such as diameter and orientation, on critical heat flux of both organics and water have been investigated. Bubble parameters (diameter vs time, maximum diameter, frequency, waiting and growth times) have been measured, as a function of heat flux and subcooling, by boiling water in horizontal tubes of stainless steel. (tr-auth)

**1512** (SAN-650-2) ORGANIC RANKINE CYCLE FEASIBILITY DEMONSTRATION PROGRAM. Quarterly Report No. 2, June 30–September 30, 1966. Baenteli, G. (Aeronutronic Div., Philco Corp., Newport Beach, Calif.). Oct. 10, 1966. Contract AT(04-3)-650. 26p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

An evaluation of monoisopropylbiphenyl as the working fluid in a Rankine cycle will be made in simulated power conversion loops. The status of the 1000-hr endurance loop development, the test facility, the instrumentation, and the data aquisition system are discussed. (F.S.)

**1513** (SD-DC-66-1517) TRANSIENT STRAIN AND TEMPERATURE DISTRIBUTIONS IN LONG CIRCULAR CYLINDERS COOLED BY EMISSION OF THERMAL RADIATION. Wildin, M. W.; Pritchard, R. S. (New Mexico Univ., Albuquerque). Apr. 1966. Contract AT(29-1)-789. 25p. (CONF-661105-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Annual Meeting and Exposition of the Society for Experimental Stress Analysis, Pittsburgh, Pa.

Techniques used to experimentally and analytically determine temperature and strain distributions produced by radiative cooling of long circular cylinders are described. Analytical results were obtained by finite difference techniques. The low level dynamic thermal strains, measured by means of embedded strain gages, agreed with the predicted values within acceptable limits. Results are presented for the highest strain level and the highest temperature for which the properties of the model were known. (auth)

**1514** (TRG-Report-29) PRESSURE DROP TESTS ON 21-ROD SMOOTH AND ROUGHENED CLUSTERS. Wilkie, D.; Wilson, J. T. (Reactor Group, United Kingdom Atomic Energy Authority, Sellafield (England)). Mar. 23, 1961. 30p. (NPCC-FEWP-P.748). Dep. mn.

Results are presented of pressure loss tests on standard AGR stainless steel fuel element assemblies, and on assemblies with 21-rod smooth clusters and 21-rod screw-thread roughened clusters. A method is given which enables roughened rod cluster pressure losses to be predicted to within 10% from rough surface data obtained from a single roughened rod in a smooth channel together with pressure loss data for smooth clusters. (auth)

**1515** (AEC-tr-6630) HANDBOOK OF HYDRAULIC RESISTANCE, COEFFICIENTS OF LOCAL RESISTANCE AND OF FRICTION. Idel'chik, I. E. Translation of Spravochnik po Gidravlicheskim Soprotivleniyam, Koeffitsienty Mestnykh Soprotivlenii i Soprotivleniya Treniya, Gosudarstvennoe Energeticheskoe Izdatel'stvo, Moscow-Leningrad, 1960, 528p. (IPST-Cat.-1505). Dep. CFSTI $3.00 cy, $0.65 mn.

Data on the friction coefficients of straight pipes and channels and the coefficients of fluid resistance of fittings, throttles, obstructions, elements of hydraulic or gas-air lines, and several devices used in industrial systems for gas purification, heat exchange, and ventilation are given in handbook format. The handbook is divided into twelve sections. The first section contains general information on hydraulics and mechanics of fluids. The other sections are each devoted to a definite group of fittings or other elements of pipes and obstructions with similar conditions of fluid motion, and contain data on their fluid resistances. Each of these sections is divided into descriptive material and separate diagrams for practical calculations, each of which corresponds to a certain element of the pipe or obstruction. In most instances these diagrams contain formulas for calculating the resistance coefficient of the element as a function of its main characteristics, a graphical representation of this functional relationship, and tables of the values of the resistance coefficients. The handbook is intended for a wide range of specialists: scientists, designing and operating engineers of all branches of hydroengineering, and students of universities and technical institutes. (tr-auth)

**1516** STEAM GENERATORS OF ATOMIC POWER PLANTS. Revay, Peter (Koezponti Fizikai Kutato Intezete, Budapest). Energ. Atomtech., 19: 276-82(June 1966). (In Hungarian).

The steam generators used for atomic power plants may be classified on the basis of the cooling agent used; the radioactivity of the steam generated is also an important criterion. The following systems are used in operating power stations: gas-cooled steam generators, such as the $CO_2$-cooled systems at the British Calder Hall, Bradwell, Berkeley, Hinkley Point, the French EDF-1 and EDF-2, the Italian Latina and the Japanese Tokai Mura plants; helium-cooled system at the German AVR plant; water-cooled steam generators at the U.S. Shippingport and the Soviet Novo Voronezh plants; steam-cooled systems at the U.S. Dresden and the Soviet Beloyarsk plants; heavy-water cooled generators at the Canadian Candu plant; liquid-metal cooled generator at the U.S. Enrico Fermi plant; organic-cooled plant at the U.S. Piqua power station. In all cases, special care must be taken to ensure the purity of the coolant, in order to eliminate the danger of overheating and burnout. Recent operational experience, especially with the French reactors, indicated that it is desirable to place the steam generator behind the shield. Corrosion of the structural units of the primary circuit must be prevented. In water-cooled systems, the presence of $Cl^-$ ion is mostly responsible for the corrosion of stressed steel surfaces, therefore, the concentration of this ion must be kept below the permissible level. The Soviet experience indicates that the activity of the steam generated in the reactor is low enough to make use of such a design for generating nuclear superheated steam. (TTT)

**1517** HEAT TRANSFER LIMITATIONS ON NUCLEAR REACTOR FUEL ELEMENTS. Rogers, J. T. (Canadian General Electric, Peterborough, Ont.). Can. J. Chem. Eng., 44: 289-98(Oct. 1966).

Limitations on heat transfer rates in fuel elements in Canadian heavy-water moderated reactors are examined. With organic coolant in simple flow geometries, heat fluxes are limited by departure from nucleate boiling, (DNB); in simulated fuel bundles the failure mechanism can be either localized DNB, or coke-out, the formation, deposition and rapid growth of coolant decomposition products on heated surfaces. With boiling light water coolant, critical heat flux (CHF) is caused by DNB at low qualities and by dry-out at higher qualities. Parameters governing CHF in tubes and annuli are fairly well established. Data for fuel bundles are becoming available. Methods of increasing CHF and of rationally setting margins of safety on CHF are being developed. (auth)

# Isotope Technology

*Refer also to abstracts 1438, 1665, and 2864.*

**1518** (AGN-8163(Vol. 1)) RADIOISOTOPE APPLICATIONS IN HYDROSPACE. VOLUME I. RISE CONCEPTUAL DESIGN. Final Report. (Aerojet-General Nucleonics, San Ramon, Calif.). Oct. 1965. Contract AT(04-3)-368. 107p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

The RISE demonstration system consisting of a Dowtherm A Rankine cycle power conversion system coupled directly to a boiler fueled with the radioisotope $^{60}$Co produces 3 kW(e) continuously for 10,000 hr but is directly extrapolatable in the 2 to 20 kW(e) power range. The power conversion system (PCS) consists of a turbine, alternator and condensate pump, close-coupled as a combined rotating unit (CRU); a regenerator and condenser combined in one unit; an intermediate water-filled cooling system between the Dowtherm A condenser and the sea water-cooled vessel hull; instrumentation and controls; and a dissipative load bank. Auxiliary and emergency cooling systems are also provided. The RISE heat source consists of 19 doubly encapsulated $^{60}$Co fuel capsules in a hexagonal array at the center of a spherical tungsten shield. Heat is conducted out through the shield to a coiled Hastelloy C tube in which Dowtherm A is boiled. A spherical inner pressure vessel surrounds the coils and contains NaK used as a heat transfer medium between the shield and the boiler coil. Standoffs separate the shield and inner pressure vessel to maintain clearance for the boiler coil. An evacuated volume exists between the inner pressure vessel and a Hastelloy C outer pressure vessel designed to withstand ambient sea water pressure. The vacuum space limits heat loss during normal operation but can be filled with He in an emergency to provide a conduction heat path directly to the sea water. (auth)

**1519** (AGN-8163(Vol.4)) RADIOISOTOPE APPLICATIONS IN HYDROSPACE. VOLUME IV. DOWTHERM A RANKINE CYCLE TECHNOLOGY. Final Report. (Aerojet-General Nucleonics, San Ramon, Calif.). Jan. 1966. Contract AT(04-3)-368. 93p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Preliminary design studies of a 3 kW(e) and a 20 kW(e) power conversion system have been completed. These designs are based primarily on the service life, performance, and packaging requirements implicit in the use of such systems in a hydrospace (deep submergence) environment. The resulting systems utilize an organic working fluid, Dowtherm A, with a closed Rankine cycle. The system prime mover is a high speed turboalternator mounted on a single shaft supported on fluid film bearings. The rest of the system consists primarily of a regenerator, boiler, condenser, condensate pump, and controls. These systems provide for an overall power conversion system efficiency of more than 17% at the 3kW(e) power level and 18.4% at the 20 kW(e) power level. (auth)

**1520** (AGN-8163(Vol. 5)) RADIOISOTOPE APPLICATIONS IN HYDROSPACE. VOLUME V. DOWTHERM A HEAT TRANSFER TESTS. Final Report. (Aerojet-General Nucleonics, San Ramon, Calif.). Jan. 1966. Contract AT(04-3)-368. 33p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Boiling heat transfer experiments using Dowtherm A flowing in a 0.5 in. diameter tube at 225 lb/hr were performed at saturation temperatures of 583° (38 psia) and 664°F (80 psia) with qualities from 67 to 93%. The wall-fluid temperature differences were large compared to similar data for water. The temperature difference was found to increase as the vapor quality was increased for a given saturation temperature; however, the temperature difference decreased as the saturation temperature (boiling pressure) was increased for a given quality. All of the data are thought to lie in the partial film boiling region in which the heated surface is only partially covered by the liquid phase. (auth)

**1521** (COO-1471-7) HELICOPTER CLOSE-ORDER FORMATION KEEPING SYSTEM. Final Report. Hahn, Linus K.; Krause, Charles E.; Utt, Orval L. Jr. (Industrial Nucleonics Corp., Columbus, Ohio). Aug. 11, 1966. Contract AT(11-1)-1471. 110p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

An isotopic gamma-ray signaling system to permit close-order formation keeping in helicopters within a range of from 50 to 500 feet is described. A successful ground demonstration of the Helicopter Formation Keeping System was performed. The system concept uses a modulated gamma-ray source and fixed gamma-ray detector array on each helicopter. The feasibility demonstration proved that a fixed gamma-ray detector array can differentiate between signals from two modulated gamma-ray sources. The signals were processed to provide a display similar to a PPI-type display. The display indicated the proper bearing and spacing between the two sources and the detector array. Phase II has been authorized to develop and demonstrate a flight model of the system with Navy participation through the Atomic Energy Commission. (auth)

**1522** (GA-5317) SNAP-15A THERMOELECTRIC GENERATOR. Final Report, May 6, 1963–September 30, 1964. Baker, F. S.; Campana, R. J.; Sargent, W. S. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Contract AT(04-3)-167. 118p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

The design and performance of the SNAP-15A thermoelectric generator are described. Heat is supplied by the decay of radioactive $^{238}$Pu contained in a fuel capsule held in place by a capsule holder. The capsule holder is recessed at one end into which the hot junctions of the thermocouples are fitted with a silicone rubber to form one end of the thermopile. The thermopile consists of 1300 thermocouples made from wire 2 mils in dia. The design specifications for the generator require the production of about 1 milliwatt of output power at greater than 4.5 volts for 5 years with very high reliability even under extreme environmental conditions. Materials and process development, fabrication and quality control, test evaluation, reliability, and safety testing of the generator are described. (R.C.K.)

**1523** (NAA-SR-11945(Vol.1)) MERCURY RANKINE PROGRAM INTEGRATED SYSTEM TEST (PSM-3). VOLUME I. SYSTEM OPERATION. LeBlanc, J. G.; Poucher, F. W. (Atomics International, Canoga Park, Calif.). Oct. 25, 1966. Contract AT(11-1)-Gen-8. 114p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

A complete non nuclear mercury Rankine orbital startup simulator system producing an average of about 3 kW(e) was successfully fabricated and operated for 706 hr. and 108 startups. The system, designated PSM-3, was the third in a series of three Prototype System Mockups fabricated and operated at Atomics International as part of the SNAP-2 program (later redirected as the Mercury Rankine Program). The major objectives and accomplishments of the system test, the program plan, test operations, and an evaluation of the test results with regard to the Mercury Rankine Program are described. Volume II presents the detailed analysis and correlation of the test data. (auth)

**1524** (NAA-SR-11945(Vol.2)) MERCURY RANKINE PROGRAM INTEGRATED SYSTEM TEST (PSM-3). VOLUME II. DATA CORRELATION. Heiskala, V. (Atomics International, Canoga Park, Calif.). Oct. 25, 1966. Contract AT(11-1)-Gen-8. 172p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Three Prototype System Mockups have been fabricated and operated at Atomics International. They were initially operated as part of the SNAP-2 program which was recently redirected as the Mercury Rankine Power Conversion Technology program. The third system, PSM-3, which was instituted to study the startup and operation of the SNAP-2 system in a simulated zero-gravity environment, successfully operated for 706 hours and 108 startups. Volume I describes fabrication and operation of the PSM-3 system. Volume II presents the analysis and correlation of the test data. (auth)

**1525** (NYO-3491-1) GENERATION AND PRACTICAL USE OF MONOENERGETIC X-RAYS FROM ALPHA EMITTING ISOTOPES. Annual Report. Sellers, Bach (Parametrics, Inc., Waltham, Mass.). Jan. 1966. Contract AT(30-1)-3491. 63p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Many analytical applications of x-ray techniques, for instance composition analysis, require that the x-ray spectrum possess a high degree of monochromaticity. The possibilities of satisfying this requirement through generation of characteristic x radiation as a result of the interaction of various radiations with materials are summarized. The advantages of using radioactive alpha particles as the exciting radiation, including the lack of any significant bremsstrahlung or scattered source radiation, are pointed out. Experimental results on the characteristic x-ray yield as a result of radioactive alpha bombardment are presented, and these yields are shown to be in theoretical agreement with those observed by other investigators using proton excitation. (auth)

**1526** (SC-TM-66-393) A SIX-DEGREE-OF-FREEDOM INVESTIGATION OF THE MOTION OF TWO SNAP FUEL CAPSULE CONFIGURATIONS RE-ENTERING THE ATMOSPHERE WITH VARIOUS INITIAL CONDITIONS. Johnson, D. H. (Sandia Corp., Albuquerque, N. Mex.). Sept. 1966. Contract AT(29-1)-789. 26p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The aerodynamic characteristics of two SNAP fuel capsule configurations were determined by using Newtonian theory. For one of these configurations (a cylindrical body with hemispherical end caps), several six-degree-of-freedom trajectories were run using the NASA Six-Degree-of-Freedom Program on the IBM 790 machine in order to study its motion as it re-entered the atmosphere from orbit around the earth. Particular attention was paid to the tumbling motion. Also, a literature search was made to determine

what has been done in the way of measuring the aerodynamic characteristics of right circular cylinders. A summary of the available experimental data is given, and a comprehensive bibliography is included in the report. (auth)

**1527** (USNRDL-TR-1050) RADIOACTIVITY RELEASE FROM RADIONUCLIDE POWER SOURCES. III. RELEASE FROM PLUTONIUM METAL TO SEAWATER. Lai, M. G.; Goya, H. A. (Naval Radiological Defense Lab., San Francisco, Calif.). July 11, 1966. Contract AT(49-5)-2084. 45p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The rates and extent of radionuclide release to seawater from various isotopic fuel material were determined to study the behavior of Pu metal in seawater. It was found that Pu metal reacts completely with natural seawater to produce solid reaction products, believed to be plutonium oxide and/or hydroxide, and a gaseous product whose major component is H. The rate at which the reaction occurs is fairly rapid; 90% of a 60-mg sample reacted in less than 5 hr. The mole ratio of reacted Pu to evolved H is unity. The mixture resulting from the reaction of Pu metal with seawater contains a non-uniform distribution of solids, and ionic and complexed species. In order to reproducibly sample this heterogeneous mixture, an experimentally determined sampling procedure must be followed which produces uniform results. In this sampling system Pu in solution is defined as all those species which pass through a 0.45-$\mu$ membrane filter (Millipore). The maximum rate at which Pu solid reaction products enter into "solution" in seawater is very slow, approximately 1.5 to 2 $\mu$g per day per 50–70 mg of solids in seawater. The driving force of the reaction is toward the complexed forms, Pu solids dissolve. The effect of individual complexing anions on the solubility of the Pu solids was found to be additive. The equilibrium (or maximum) concentration of dissolved Pu in three samples of natural seawater was found to be 67 $\mu$g/l. For seawater samples taken at different localities or at different times of the year, deviations from this value can be expected due to differences in the concentrations of complexing anions present. The length of time for attainment of the equilibrium condition varied with mixing conditions. (auth)

**1528** SEPARATION OF STABLE ISOTOPES OF THE RARE EARTHS. Formann, E.; Lugmair, G.; Ruedenauer, F.; Viehboeck, F. P.; Wotke, H. (Reaktorzentrum, Seibersdorf, Austria). Acta Phys. Austr., 23: 55-63(1966). (In German).

The mass separator used at the Seibersdorf reactor center for the separation of stable rare-earth isotopes is described. The ion source, the extraction system, and the collection system is considered in some detail. The efficiency of the installation is illustrated. (J.S.R.)

**1529** NUCLEAR POWER SYSTEMS. Schulman, Fred. Space/Aeronaut., 46: No. 2, 124-6(Mid July 1966).

Development work on radioisotopic generators using $^{238}$Pu, $^{244}$Cm, $^{242}$Cm, $^{147}$Pm, $^{210}$Po, and $^{170}$Tm heat sources is summarized. The advantages and disadvantages of GeSi and PbTe thermoelectric elements are discussed. Brayton cycle systems are evaluated including their applicability to isotopic power systems. Development work on isotopic power systems for SNAP-19 and 27 is briefly discussed. Progress on reactor systems for SNAP-8 and 50 is summarized. (F.S.)

**1530** UTILIZATION OF VARIOUS RADIOISOTOPIC DEVICES AND METHODS IN THE OIL AND CHEMICAL INDUSTRIES. Dzhagatspanyan, R. V.; Drobiz, A. M. 23p. (In Russian). (CONF-641024–12). ORAU.

From Symposium on Use of Radioisotopes, Warsaw.

Radioisotopes are used in measurement and control equipment, as tracers, and for inducing chemical reactions. The radioisotope-containing gages, discussed here, provide for contactless and remote measurement of process and product variables, which is especially important when the reagents are corrosive or at high temperatures or pressures. Any effect of external conditions is thus eliminated, and measurements are made more rapidly. More than sixty such instruments have been developed in the USSR for measuring, for example, concentrations, levels, densities, and thicknesses. Their use in various industries is estimated to result in an annual saving of 240,000 rubles ($260,000). Some of the variables measured or controlled are: concentration of sulfur in diesel fuel; levels in high-pressure separators (walls 200 to 300 mm thick) in coking plants, tank cars, and thermal cracking columns; charging of lime to furnaces for production of calcium carbide; production of Metafos (insecticide) and Freon; process of concentrating weak nitric acid; and the amount of the gamma isomer in hexachlorocyclohexane, which determines its insecticidal properties. (TTT)

**1531** USE OF RADIOISOTOPES IN CONCRETE TECHNOLOGY FOR ACCELERATING HARDENING PROCESSES AND IMPROVING ITS CONTRACTION AND EXPANSION PROPERTIES. Novakovski, Boleslav. 15p. (In Russian). (CONF-641024–11). ORAU.

From Symposium on Use of Radioisotopes, Warsaw.

Irradiation with gamma rays from a $^{60}$Co source increased the rate of hardening of cement, but no effect on the final hardness of the product was observed. Mixes irradiated to 6000–600,000 rads were 47% more resistant to pressure on the third day after irradiation and 10% more resistant on the twenty-eighth day. This result is due to the dynamic state of the multiphase cement-water mixture, which contains crystals, colloids, molecules, and aqueous solutions. Any solids present are finely divided and, therefore, have a large surface area in contact with the aqueous phase. The radiation affects this surface, where new centers of solid phase growth arise, resulting in a better network of the matrix structure. The optimum radiation dose for accelerating the hardening process was not determined. The possible implications of these results to the economics of the concrete industry are discussed. (TTT)

## Materials Testing

*Refer also to abstracts 1500, 1667, and 1892.*

**1532** (N-66-22356) TWO STAGE POTASSIUM TEST TURBINE. Quarterly Progress Report No. 17, May 8–August 8, 1965. Schnetzer, E. (ed.) (General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section). Nov. 24, 1965. Contract NAS5-1143. 305p. (NASA-CR-54897). CFSTI $7.00 cy, $1.75 mn.

A two-stage test turbine was successfully performance tested in potassium vapor at temperatures of 1450 and 1550°F. Seventy-two performance data points were obtained within specified tolerances and the evaluation of these results is presented. The performance agreed well with calculated performance and was repeatable. Disassembly of the turbine revealed no significant damage except to the main bearing which was inadvertently deprived of lubricating oil momentarily. No erosion was observed but deposition of containment material constituents occurred on exposed parts. The facility operated stably and suffered no damage. (STAR)

**1533** (UCID-4868) ACOUSTIC EMISSION RESEARCH. Status Report, December 1963–August 1964. Dunegan, H. L.; Tatro, C. A.; Harris, D. O. (Lawrence Radiation Lab., Univ. of California, Livermore). Nov. 24, 1964. Contract W-7405-eng-48. 30p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The results of a new experimental approach to detecting and recording the acoustic emission of materials when subjected to strain is discussed. Specimens in the form of diaphragms are loaded by means of hydraulic pressure. The acoustic energy emitted from the specimens is detected with transducers having fundamental frequencies to 1 Mc. The detection is accomplished by immersing the specimen in water and using the water for coupling the acoustic energy to the transducer. Results are shown of acoustic emission of anodized 6061 aluminum and beryllium diaphragms. It is demonstrated that the yield point of the aluminum and the development of microcracks leading to failure in beryllium can be recorded. Three possible applications of the acoustic emission phenomenon are given. (auth)

## Protective Structures

*Refer also to abstract 2919.*

**1534** (AD-629607) SIMULATION DEVICES FOR USE IN STUDIES OF PROTECTIVE CONSTRUCTION. Technical Report, January 1, 1965–December 31, 1965. Mahoney, James A. (Air Force Weapons Lab., Kirtland AFB, N. Mex.). Feb. 1966. 225p. (AFWL-TR-65-224). CFSTI $6.00 cy, $1.25 mn.

Dynamic loading simulation devices that were either designed or could be modified for use in studies of protective construction are described. Included are the following: (1) type of device, (2) owner and location, (3) loading characteristics, (4) physical description, (5) driver used, and (6) a short discussion concerning the device and its present use. Pictures and diagrams are also included for the majority of the devices. (auth)

**1535** (AD-640026) BRECKENRIDGE BLAST-ACTUATED CLOSURE VALVE. Breckenridge, R. A. (Naval Civil Engineering Lab., Port Hueneme, Calif.). Sept. 1966. 61p. (R-481). CFSTI $3.00 cy, $0.75 mn.

The ventilation systems of shelters providing blast protection must have automatic valves to prevent ingress of damaging pressure waves through the air ducts. The development, testing, and evaluation of a blast-actuated closure valve at the U. S. Naval

Civil Engineering Laboratory is described. For ventilation the valve has a rated airflow of 700 cfm. It provides protection from blast overpressures up to 150 psi. It also provides protection during the negative phase following any blast wave. When installed as intended, the valve should be relatively insensitive to the thermal pulse and ground accelerations associated with nuclear explosions. It is also insensitive to environmental conditions. Its operation is simple and reliable, and resetting is unnecessary because of the valve's automatic response. It requires no maintenance. (auth)

**1536** (AD-640440) MOTION OF SUBSURFACE SOIL INCLUSIONS SUBJECTED TO SURFACE BLAST LOADING: RESULTS OF SERIES II TESTS. Heller, L. W. (Naval Civil Engineering Lab., Port Hueneme, Calif.). Oct. 1966. 57p. (R-483). CFSTI $3.00 cy, $0.50 mn.

Tests were conducted to determine how shape and mass affect the motion of buried inclusions subjected to blast loading applied to the surface of the soil. Five inclusions, representing elemental portions of a buried complex, were placed 6 inches below the surface of a dry sand material sieved into a reinforced-concrete test container. Two of the inclusions had the same shape and stiffness but differed in mass. The three other inclusions had comparable mass and stiffness but differed in shape. The displacement and acceleration of the inclusions and the displacement of the soil at two elevations were measured during a sequence of 13 blast loadings at peak overpressure levels of 5 to 25 psi. Reed gages were attached to one inclusion and cantilevered into the soil to indicate the motion of the inclusion with respect to the surrounding soil. Accurate measurement of inclusion motion was not made. However, the following results were obtained: reed gages indicated that the inclusion displaces into the soil in the direction of the propagated soil stress wave, an increase in the mass of an inclusion by a factor of 13 only halved its peak acceleration, and differences in shape of the inclusions tested resulted in only 10% to 15% differences in their peak accelerations. A tentative method for estimating the blast-induced differential motion between a structural inclusion and its surrounding soil field is described. (auth)

**1537** (N-66-21662) CALCULATION OF THE DEEP PENETRATION OF RADIATION BY THE METHOD OF INVARIANT IMBEDDING. Mathews, Donald Richard (Massachusetts Inst. of Tech., Cambridge. Dept. of Nuclear Engineering). Feb. 1966. 129p. (NASA-CR-71388). CFSTI $4.00 cy, $1.00 mn.

Thesis.

The method of invariant imbedding has been applied to energy dependent shielding problems with anisotropic cross sections. The method seems to offer advantages over competing methods when the shield is either very heterogeneous or heterogeneous and very thick. Plane geometry reflection and transmission equations are derived using the method of invariant imbedding and their numerical solution is discussed. A simple exponential approximation is shown to work well for the solution of these equations. Results for several problems, including thick water and thinner iron polyethylene/iron shields, are given and compared with other methods. (STAR)

**1538** (ORNL-TM-1622) ATTENUATION OF SHOCK WAVES IN TUNNEL SHELTERS. Newman, John (Oak Ridge National Lab., Tenn.). Sept. 8, 1966. Contract W-7405-eng-26. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Based on the wind resistance behind the shock wave, it is estimated that, for a blast wave with 100-psi peak overpressure and a 2-sec positive phase duration (corresponding to a 10-Mt burst), the shock overpressure is reduced to 5 psi after traveling through 400 ft of 8-ft tunnel containing 5 $ft^2$ of attenuator surface per ft of tunnel. Even for a sustained overpressure of 100 psi at the opening, the shock overpressure is reduced to 5.3 psi in the same distance, although in this case the pressure after the shock wave has passed will still rise slowly to 100 psi (in the order of tenths of seconds). (auth)

## Radioactive Material Handling

*Refer also to abstracts 1491 and 1493.*

**1539** (AE-234) RECIPIENT CAPACITY OF TVAEREN, A BALTIC BAY. Agnedal, P-O.; Bergstroem, S. O. W. (Aktiebolaget Atomenergi, Stockholm (Sweden)). July 1966. 21p. Dep. mn.

The research station located at Studsvik on the Baltic coast is described. The research center includes several reactors and laboratories, and a waste disposal plant serving both the station and waste producers outside Studsvik. A storage plant for irradiated fuel from power reactors has also been built. The composition of the waste is varied and difficult to predict. Minor amounts of fission products, active corrosion products, and fissile materials have been detected. Most of the waste activity is released to a strait leading into the Bay. Large volumes of water with very low specific activity are released immediately off the coast. Permissible releases have been calculated using relevant accumulation factors. Fission products and corrosion products seem to be of similar significance with regard to possible human exposure. Permission to release liquid waste is granted by water courts in Sweden and operations are inspected by special authorities. As the water court procedure takes a long time and is very expensive it is suggested that the verdict should only take hydrology and the formal assumptions as to diet and behavior of the exposed categories into account. Methods for fixing biological accumulation factors for different radionuclides are also discussed. (auth)

**1540** (IAEA-3431-3) INVESTIGATION OF MATERIALS AND METHODS FOR FIXATION OF LOW AND MEDIUM LEVEL RADIOACTIVE WASTE IN STABLE SOLID MEDIA. Progress Report, November 1, 1965–July 31, 1966. Rastogi, R. C.; Sehgal, J. D.; Thomas, K. T. (Atomic Energy Establishment, Trombay (India)). 1966. Contract 261/RI/US. 43p. (AEET-266). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Methods are described for preventing ruthenium volatility during glass fixation process of sludge and vermiculite type of wastes using different reducing agents; and trapping volatilized ruthenium in iron oxide coated silicious bed material up to a column temperature of 350°C and air flow rate of 0.15 fps with an efficiency in the order of 99.9%. An analytical procedure for estimation of ruthenium with a spectrocolorimeter is described. Results and composition of low temperature fusing glasses between 750°C and 950°C, incorporating the above type of inactive waste with different fluxing agents are presented. Operation of 20 kW pilot plant furnace and results of fusion studies up to 5 kg batch of actual inactive Chemical Treatment Plant sludge and vermiculite mixed with fluxes are described. Third stage pilot plant flow sheet introducing an induction heated melter pot for fusing actual waste is presented. Proposed future work on corrosion studies, controlled crystallization, phase systems studies of cesium compound with other compounds to form a stable substance at higher temperatures and tracer studies in the pilot plant furnace are discussed. (auth)

**1541** (ISO-SA-27) PLUTONIUM SCRAP MEASUREMENTS. Bruns, L. E.; Doerr, R. W. (Isochem Inc., Richland, Wash.). Sept. 19, 1966. Contract AT(45-1)-1851. 15p. (CONF-661011-5). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From AEC Contractors' Nuclear Materials Management Meeting, Berkeley, Calif.

Four types of plutonium scrap (slag and crucible, incinerator ash, power reactor fuel scrap, and hood waste) are reviewed in relation to processing and measurement applications. Special scrap measurement instrumentation is discussed together with techniques for reducing the alpha–neutron effects in scraps containing varying plutonium compounds. A new 384-keV gamma counter demonstrates a new trend in scrap measurement techniques. Development projects under study include a precise solid sampling program and continued instrumentation development. The overall program shows the increasing emphasis being placed upon scrap measurements. (auth)

**1542** (NAA-SR-Memo-5975) CRITICALITY STUDY FOR HALLAM FUEL FABRICATION AND SHIPMENT. Ketzlach, Norman (Atomics International, Canoga Park, Calif.). Dec. 16, 1960. Contract AT(11-1)-Gen-8. 25p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

In calculating criticality parameters for Hallam fuel elements it was found that it is safe to handle 60 slugs (1.8 Kgm contained $^{235}U$) of 0.59-in. dia having a maximum length of 12 in. Where there is no control of fuel geometry (e.g. sawdust, chips, etc.), the maximum safe batch size should contain no more than 0.94 Kgm contained $^{235}U$. Where there is no control of spacing between fuel rods, the maximum safe number is 29. The 60-rod retort and Lazy Susan are safe as designed. The 120-rod storage rack should be modified by the insertion of a Cd liner (≥0.020-in. thick) or a boral liner (≥0.25-in. thick). A plate or other means of obstruction should be fixed in position over the top of the central hole of the storage rack to prevent placing rods inside. Four 18-rod clusters are safe independent of lattice spacing or the degree of water flooding. Six shipping boxes are also safe under the same conditions. A single plane array of safe batches of slugs, or between fuel batches where there is no control of fuel piece size, is safe with an edge-to-edge separation of 24 in. between batches. Infinite arrays of fuel rods, shipping boxes of fuel rods, and 18-rod clusters are safe with center-to-center spacings of 10.7 in., 48 in., and 28 in., respectively. Criteria for safe separation between fuel groupings in finite arrays are also presented. (auth)

**1543** (WAPD-TM-632) CRITICAL DIMENSIONS OF $^{235}U$ AQUEOUS SYSTEMS CONTAINING $^{238}U$ OR $^{232}Th$. Jones, L. L.

Jr.; Romesburg, H. C. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1966. Contract AT-11-1-GEN-14. 26p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Criticality data for homogeneous water moderated and reflected systems containing $U^{c}O_2$ and thoria were analyzed to provide data that will be used to establish fuel handling and storage criteria for finely divided mixtures and alloys of $U^{c}O_2 + ThO_2$. Homogeneous, water reflected and moderated spheres of thoria containing a wide range of $U^{c}O_2$ wt % have been analyzed by four-group diffusion theory utilizing the one-dimensional code WANDA. The fast-group constants were obtained from the MUFT 5 code which weights a 54-group microscopic cross-section set over a spectrum determined by the buckling and material composition and coalesces these into three fast-group constants. The thermal-group constants were obtained with the KATE 1 code using the "mixed number density" option. Stearic acid and sugar were compared with water for effectiveness of moderation and reflection. Water proved to be the best moderator thus far, but sugar (at theoretical density) proved to be superior to water as a reflector. (auth)

**1544** (JPRS-36824) MAINTENANCE OF REACTOR SAFETY WHEN WORKING WITH FISSIONABLE MATERIALS. Kamaev, A. V.; Kuznetsov, F. M.; Vladykov, G. M.; Dubovskii, B. G. Translated from pp 1–14 of Obespechenie Yadernoii Bezopastnosti pri Rabote s Delvashchimisya Veshchestvami, Power Engineering Physics Institute, Obninsk, 1965. 14p. (TT-66-33254). CFSTI $1.00 cy, $0.50 mn.

Factors necessary for maintaining reactor safety when working with uranium of unknown concentration and large amounts of uranium solutions are discussed. The limiting dimensions of vessels containing uranium should be less than the minimum critical values of these dimensions. The volume of uranium solution must not exceed the respective minimum critical volumes for metallic uranium or solution of uranium. Boron and cadmium are employed as neutron absorbers when storing and processing large quantities of fissionable materials. Studies are being made on the effectiveness of neutron absorbers in aqueous solutions of uranyl nitrate with 90% enrichment. (H.L.W.)

**1545** TREATMENT OF RADIOACTIVE WASTE IN PRACTICE. Hekman, H. (Instituut voor Toepassing van Atoomenergie in de Landbouw, Wageningen, Netherlands). Ingenieur (Utrecht), 78: No. 23, G13-14(June 10, 1966). (In Dutch).

Because of the increasing use of radioactive substances in industry and research the problem of treatment and removal of radioactive waste had to be solved. The treatment and disposal of waste from the agricultural research center in Wageningen were centralized in the radioactive waste department of the Institute for Atomic Sciences in Agriculture. Measures taken in the treatment and disposal of radioactive laboratory wastes of the low-level or medium-level type are described. (auth)

**1546** POWER MANIPULATOR. Tsuda, Eiichi; Shikata, Sanji (Mitsubishi Electric Mfg. Co., Ltd., Japan). Mitsubishi Denki Giho, 40: 1182-7(July 1966). (In Japanese).

Electrically operated remote control equipment for handling radioactive materials, built for the purpose of operating inside a large hot cave to manipulate heavy articles is described. The equipment was manufactured by the Atomic Energy Establishment in Trombay, India and shipped to the destination in July 1965. The power manipulator and an electric hoist are set up on the same gantry for ease of handling the control cables and a large operating space. It has a selective call device with which a number of control signals are sent over one cable in operation. (NSA of Japan)

**1547** METHOD OF FABRICATING ENCLOSED RADIOACTIVE PREPARATIONS WITH $^{204}Tl$. Vormum, Guenther; Muenster, Hans-Juergen (to Deutsche Akademie der Wissenschaften). German Patent 1,222,591. Aug. 11, 1966. Filed Dec. 24, 1960.

A method of enclosing radioactive preparations with $^{204}Tl$ is described which employs a grooved base plate of copper or silver, uniformly distributed $Tl_2O_3$ powder in the grooves, wetting the powder with a solution of zapon varnish in acetone, reduction in hydrogen atmosphere, and enclosing the layer with a metal foil which is pressed upon the base plate at an elevated temperature. (Gmelin Inst.)

**1548** DEVICE FOR CONTAINING USED RESIN. Muto, Takeo (to Hitachi Ltd.). Japanese Patent 1965-28960. Oct. 6, 1965. Filed Feb. 26, 1963.

A container was designed for easy observation of used resin. The container is placed on the top of a reactor vessel. The transparent cylindrical container body is surrounded by a shield containing holes used to observe the used resin. A pipe system is used to conduct the resin to the container. (TSS)

**1549** IRRADIATION FACILITY WITH RADIOACTIVE RADIATION SOURCES. Baur, Peter (to Gebrueder Sulzer Aktiengesellschaft). German Patent 1,221,369. July 21, 1966. Priority date Mar. 11, 1965, Switzerland.

The irradiation facility is comprised of a vertically movable plate within a shielded irradiation chamber provided with parallel, horizontal channels in which the radioactive sources are located, and a means for exchanging simultaneously the radiation sources in two neighboring channels. The radiation sources are exchanged by means of a horizontal port in the concrete shielding wall, a stepped steel sleeve lining the wall of the port, and within the sleeve, a fixed lead plug adjacent to irradiation chamber, which is provided with two channels to be brought into alignment with two of the parallel channels in the source plate when the plate is vertically moved, and a rotatable plug facing the outside of the shielding wall which is supported on ball bearings and is penetrated by one eccentric channel which is brought into alignment with the channels in the fixed plug when the outer plug is rotated. (Gmelin Inst.)

## Vacuum Engineering

**1550** 1965 TRANSACTIONS OF THE THIRD INTERNATIONAL VACUUM CONGRESS, 28 JUNE–2 JULY 1965, STUTTGART, GERMANY. VOLUME I. INVITED PAPERS. Adam, H. (ed.). New York, Pergamon Press, 1966. 175p. (CONF-650643).

Separate abstracts were prepared for 7 of the 13 papers included. The remaining 6 papers contain information on the transition of gases from dynamic to molecular flow, sorption on solids, freeze drying, vacuum science and technology in space, and advances in vacuum metallurgy. (R.C.K.)

*For abstracts of individual papers see: 1551–1556 and 2055.*

**1551** EXCITATION OF SPIN WAVES AND KERR EFFECT ON THIN FERROMAGNETIC FILMS. Van Itterbeek, A.; Witters, J.; Vrambout, R. (Instituut voor Lage Temperaturen en Technische Physica, Leuven, Belg.). pp 17-20 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

Review of some investigations on the magnetic properties of thin iron and permalloy films is given. Measurements of the coercive field as a function of temperature by the Kerr effect method and the observation of spin waves by ferromagnetic resonance experiments are discussed. It is concluded that the experimental results can be explained but that the uncertainty about thin film parameters reduces the applicability of these results. (auth)

**1552** RESEARCH IN GREAT BRITAIN ON VACUUM DEPOSITED CONDUCTING RESISTIVE AND INSULATING THIN FILMS. Balmer, J. R. pp 21-7 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

The increased volume and quality of research on thin films in Great Britain over the past decade is summarized. This increase is due partly to the improvement of equipment available but mainly to the demands of the expanding electronics industry for thin film micro-circuit components. The organization of British thin film research, including the contribution of the Dielectrics Evaporation Group, is described. Descriptions of the more recent research on nucleation and growth, stress, electrical properties, applications and advances in methods are given. Some future possibilities are also discussed. References are given to enable more recent developments to be followed. (auth)

**1553** STRUCTURE AND PROPERTIES OF THIN FILMS. Neugebauer, C. A. (General Electric Research Lab., Schenectady, N. Y.). pp 29-40 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

If a thin film were only a slice of bulk material, its properties would be unique only because of their thickness dependence. In practice, however, a film is almost always deposited by a process which involves the condensation of atoms or molecules on a substrate under various conditions of supersaturation. The structure of a film is usually different from the annealed bulk state, and is entirely dictated by deposition conditions. The structure and properties of thin films are discussed in terms of their deposition conditions. Conditions which determine the film continuity, surface roughness, grain size, lattice defect density, crystalline orientations, composition and film purity are discussed. Vapor deposited metal films and their electrical, magnetic, mechanical, and superconductive properties are emphasized. (auth)

**1554** GAS SORPTION BY SURFACES COOLED TO LOW TEMPERATURES. Hengevoss, J. pp 51-63 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

Research on the interaction of gas molecules with solid surfaces

is described. Research work has mainly been carried out at relatively high pressures. It is only in the last few years that, with the development of ultrahigh vacuum techniques, the study of sorption and desorption processes at low pressures has gained interest. By the means of sorption processes, especially on cold surfaces, it is possible to obtain great pumping speeds in vacuum systems. The molecules of oversaturated vapors adhere on cold surfaces by adsorption. The final pressure is limited by the vapor pressures of the saturated vapors, it is important, therefore, to evaluate the vapor pressure curve in the low pressure range by experiment or calculation. The pumping speed of a surface depends upon the probability of the striking molecule remaining fixed. The interesting question is, by which parameter this probability of adsorption is influenced. The molecules of unsaturated vapors and of permanent gases can only adhere by adsorption directly to the solid surface. The adsorption isotherms indicate how large the adsorption capacity of a surface with a given temperature and given pressure is. From the Potential Theory of Polanyi analytical formula for adsorption isotherms for low coverage rates can be deduced. Condensing vapors are able to incorporate molecules of unsaturated vapors or permanent gases in their condensates. This effect, called "cryo-trapping effect" can also be used for the generation of vacuum. (auth)

**1555** DEVELOPMENTS IN THE MEASUREMENT OF LOW PRESSURES. Kornelsen, E. V. (National Research Council, Ottawa). pp 65-73 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

A number of recently developed ionization gages are compared as to their low pressure limits, sensitivity to electronic desorption effects, linearity with pressure, sensitivity and outgassing rate. A summary is also given of some simple methods of ultrahigh vacuum gas analysis which employ total pressure gages and adsorption-desorption techniques. The information obtained by these methods is compared with that given by a mass spectrometer. Finally, a brief status report is given of a number of methods of low pressure ionization gage calibration. (auth)

**1556** THE VACUUM SYSTEM OF NIMROD. Grossart, G. S. (Rutherford Lab., Chilton, Eng.). pp 89-110 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

The intense and variable magnetic field and high levels of irradiation are two of the special conditions imposed upon the design of the vacuum chamber for Nimrod, the 7 GeV Proton Synchrotron at Chilton, England. Reasons are given leading to the choice of epoxy resin and fiber glass cloth as the materials of construction of what is probably the largest laminated plastic high vacuum chamber ever made. The method of manufacture and repair of leaks are briefly described. Difficulties encountered in testing and installing the fragile chamber are discussed. The pumping equipment for this chamber comprises 40 oil diffusion pumps of 60 cm diameter, with separate roughing pumps and these and the control and interlock arrangements are described. Fast acting valves and other protective devices are incorporated. The linear accelerator injector for Nimrod has a pumping system using mercury diffusion pumps which have traps automatically charged from a liquid air manufacturing and distribution plant. The radio frequency assembly of the linear accelerator has about 300 demountable water to vacuum seals and the special vacuum testing procedure developed to ensure leak tightness is described. (auth)

# INSTRUMENTATION

## Radiation Detection Instruments

*Refer also to abstracts 1303, 1328, 1445, 1521, 2301, 2368, 2651, and 2687.*

**1557** (AD-629059) SUPERCONDUCTING NUCLEAR PARTICLE DETECTOR. Quarterly Progress Report, August 15, 1965–December 31, 1965. Spiel, D. E. (Atomics International, Canoga Park, Calif.). Dec. 31, 1965. Contract DA-18-035-AMC-107(A). 25p. CFSTI $1.00 cy, $0.50 mn.

The mechanisms involved in the detection of alpha particles by thin superconducting films have been further examined. In particular, the alpha-particle induced, self-recovering, voltage pulses were studied in some detail. Experimentally, the problem of obtaining useful information from these pulses is difficult because the signal-to-noise ratio is poor and the pulses are very fast. Attempts were made to increase pulse amplitudes by increasing film resistivity, but although some success was achieved, the increases were not adequate to significantly relieve the problem. Critical currents were increased in several films by placing ground planes over the detectors, but this increase did not result in enhanced pulses. The ground plane experiments did show, however, that thermal spike radii measurements are insensitive to the inhomogeneous current distributions which exist in films without ground planes. The distribution of pulse amplitudes with and without ground planes was measured and found to be very broad in both cases. The problem of theoretically describing the pulses is complex, since a multitude of dynamic features must be considered. (auth)

**1558** (AD-634299) INSTRUMENTATION TO MEASURE THE RATE OF ION PRODUCTION IN THE UPPER ATMOSPHERE DURING AN AURORA. Final Scientific Report, May 15–November 14, 1965. Hedblom, Edwin R.; Reidy, William P.; Doiron, Clifton (American Science and Engineering, Inc., Cambridge, Mass.). Apr. 22, 1966. Contract AF 19(628)-5178. 75p. (AFCRL-66-301). CFSTI $3.00 cy, $0.75 mn.

An ion chamber designed to measure the rate of ionization in the upper atmosphere during an aurora is described. The details of the instrument's design, operation, and calibration are presented. The flights of two ion chambers on two Astrobee 200 rockets launched from Fort Churchill, Manitoba, Canada, in January 1966 are described in detail. (auth)

**1559** (AD-634658) MOESSBAUER SPECTROMETER. Allard, Edward F. (Army Engineer Research and Development Labs., Fort Belvoir, Va.). June 1966. 9p. CFSTI $1.00 cy, $0.50 mn.

The theory and operation of a Moessbauer spectrometer are described, specifically for study of the microstructure of azides and picrates. (TAB)

**1560** (AD-634684) SUPERCONDUCTING THIN-FILM NUCLEAR PARTICLE DETECTORS. Greer, James B.; Sullivan, Donald B.; Van Antwerp, Walter R. (Army Nuclear Defense Lab., Edgewood Arsenal, Md.). June 1966. 14p. CFSTI $1.00 cy, $0.50 mn.

It was found that a thin superconducting film can be used as a detector of nuclear particles. Although the potential speed and noise advantages have not been fully realized, the results obtained are thought to be very promising and in no way suggest that these sought-after advantages may not be attainable. (auth)

**1561** (AD-640976) TERRESTRIAL MAGNETIC FIELD EFFECTS ON AN ELECTROSTATIC ANALYZER. Kuck, George A. (Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.). May 1966. 37p. (AFCRL-66-377). CFSTI $2.00 cy, $0.50 mn.

A uniform magnetic field perturbation of the 1/r coulomb field between the plates of a spherical quadrant electrostatic analyzer was calculated using action-angle variables. The effect of the uniform earth's magnetic field on the electrostatic analyzer flown on satellite 1963-25$\beta$ was shown to be negligible for particle energies above 10 keV. For electron energies below 1 keV, the perturbation of the electron trajectories would not be negligible for analyzer plates with a mean radius of 5 cm. (auth)

**1562** (AE-249) OPTIMAL LINEAR FILTERS. II. PULSE TIME MEASUREMENTS IN THE PRESENCE OF NOISE. Nygaard, K. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Sept. 1966. 10p. Dep. mn.

The problem of calculating the maximum available timing information contained in nuclear pulses in the presence of noise is solved theoretically. Practical experiments show that the theoretical values can be obtained by very simple, but untraditional, means. An output pulse from a practical filter connected to a charge sensitive amplifier with a Ge(Li) detector showed a rise time of 30 ns and a noise level of less than 5 keV. The time jitter measured was inversely proportional to the pulse height and less than 30 ns for 10 keV pulses. With the timing filter shown solid state detectors can be classified somewhere between NaI scintillators and organic scintillators with respect to time resolution. (auth)

**1563** (AECL-2607) RECENT WORK WITH Ge(Li) $\gamma$-RAY SPECTROMETERS AT CHALK RIVER. Ewan, G. T.; Malm, H. L.; Fowler, I. L. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). July 1966. 58p. (CONF-660625-3). Dep. mn. AECL $1.50.

From IAEA Panel Meeting, Vienna.

A review is given of some recent work with Ge(Li) detectors at Chalk River. The development and properties of large volume coaxial detectors are discussed briefly and typical results of measurements of the resolution, efficiency, and peak-to-total ratios for these detectors are presented. Results of performance tests on encapsulated detectors are summarized. Some of the factors affecting the pulse shape from Ge(Li) detectors are considered and time distribution measurements from coaxial detectors are shown. These detectors are being used in a Ge(Li)–Ge(Li) $\gamma$–$\gamma$ coincidence arrangement and typical results are given. The use of the detectors in the experimental program at Chalk River is discussed briefly, with results from a few experiments chosen to illustrate their different applications. These include their use in experiments on nuclear decay schemes, $\gamma$ rays from nuclear reactions, neutron capture $\gamma$ rays, resonance $\gamma$-ray scattering, muonic x rays, and experiments associated with nuclear reactor development. (auth)

**1564** (ANL-7192) MEETING ON THE DESIGN OF LARGE SUPERCONDUCTING BUBBLE CHAMBER MAGNETS. Laverick, C. (ed.) (Argonne National Lab., Ill.). Mar. 1966. Contract W-31-109-eng-38. 47p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

The design of very large supermagnets with stored energies of the order of $10^9$ J and above is considered. The design programs discussed include the general programs of ANL and BNL, the ANL superconducting bubble chamber magnet, the BNL superconducting magnet, the Stanford linear accelerator center studies, and the Livermore magnet program. (J.F.P.)

**1565** (BNL-10673) BUBBLE CHAMBER DATA PROCESSING DEVELOPMENTS. Hough, P. V. C. (Brookhaven National Lab., Upton, N. Y.). Sept. 1966. Contract AT-30-2-GEN-16. 55p. (CONF-660918-7). Dep. mn. CFSTI $3.00 cy, $0.50 mn.

From International Conference on Instrumentation for High Energy Physics, Stanford, Calif.

The major developments in bubble chamber data processing are discussed specifically in measuring systems, event identification, and bubble density measurements. (B.G.D.)

**1566** (BNL-10683) PRODUCTION OF LITHIUM DRIFTED GERMANIUM DETECTORS BY AC DRIFT. Jamini, M. A. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT-30-2-GEN-16. 17p. (CONF-661020-2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 13th Annual Nuclear Science Symposium, Boston, Mass.

Thick planar detectors were produced by ac drifting. Lithium is diffused on two opposite surfaces of a p-germanium block, thus producing an $n^+pn^+$ structure with two diodes back to back. Drift then proceeds from the two surfaces on alternate half cycles of the ac field. When the two compensated regions meet, one n-contact is removed and replaced by a p-contact. Any remaining uncompensated regions are then compensated by a dc drift. The p-contact is produced by diffusing gallium-indium eutectic at 400°C. By this technique it is possible to drift as deep at 2 cm and thus to produce a large volume detector with low capacitance. (auth)

**1567** (EUR-2964.e) PROPOSAL OF A NEW COLD NEUTRON FACILITY. Meister, H. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 58p. Dep. mn.

An investigation was made to establish a cold neutron facility of the fixed-crystal type with chopper. The special idea of the arrangement proposed is to use large Bragg angles. By using a new method of double Bragg reflection, the normal disadvantage of large Bragg angles, i.e., the monochromatic beam is cancelled as it tends back towards the reactor block. The performance data claimed at the very beginning of the calculations are specified for elastic neutron scattering work: small wavelength spread ($\Delta\lambda$/

$\lambda)^{1}/_{2} = 0.01$, values of the angular divergencies (with respect to sample and detectors) and of the time-of-flight resolution adapted to the wavelength spread. With these input data the proposed facility, which will be installed for an experiment at the largest beam hold of the reactor Ispra-I (12" $\phi$ at the reactor core), supplies one with a mean neutron current through the sample (duty cycle included) of about $2 \times 10^{7}$ neutrons per minute. This number lies very close to the corresponding intensity value, which is attained by the "Three Phased Rotor Unit" installed at the HFBR in Brookhaven. (M.O.W.)

*For an abstract of the individual section see: 1568.*

**1568** (EUR-2964.e, pp 46-55) DESIGN STUDY OF A CROSS CHOPPER. Geist, H. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center).

The design of the neutron spectrometer proposed for the new cold neutron facility is described. (M.O.W.)

**1569** (UCRL-14925-T) A PERSONNEL RADIATION DOSIMETER WITH STORAGE FOR PRESET ALARM AND CONTINUOUS READOUT. Lakin, R. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 17, 1966. Contract W-7405-eng-48. 12p. (CONF-661020-5). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 13th Annual Nuclear Science Symposium, Boston, Mass.

The circuit design of a gamma radiation dosimeter is described which permits continuous monitoring of accumulated radiation dosage. An electrochemical integrating and storage device permits continuous readout in Roentgens followed by a preset audible alarm with an exponential horn tuned for maximum audio output with minimum power input. Any radiation dose rate can be monitored by selecting a G-M detector that gives the desired range. The unit described has a readout range to 200 R and will operate in a radiation field up to 1000 R/hr with an accuracy to within ±5% in an operating temperature range from 0° to 60°C. The unit weighs less than one pound and has the capability to be clipped to the user's belt, allowing freedom of activity during emergency rescue operations or other hazardous assignment. (auth)

**1570** (UCRL-17096) ROUND-TABLE DISCUSSION ON BUBBLE CHAMBERS. Alvarez, L. W. (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 9, 1966. Contract W-7405-eng-48. 42p. (CONF-660918-6). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From International Conference on Instrumentation for High Energy Physics, Stanford, Calif.

A study is presented on the data reduction of bubble chamber films from engineering and economic viewpoints. An attempt to determine a realistic value for the number of events per dollar is given for different scanning and measuring methods. (B.G.D.)

**1571** (UCRL-50126) DEVELOPMENT OF AN IMPROVED GAMMA-RAY DETECTOR OF THE MOXON-RAE TYPE. Eccles, S. F.; Frerking, C. E.; Snow, P. B. (California Univ., Livermore. Lawrence Radiation Lab.). Aug. 23, 1966. Contract W-7405-eng-48. 12p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A detector of the Moxon-Rae type having multiple gamma ray-to-electron converter plates was developed to give improved efficiency for detecting gamma rays. Lucite was chosen for the converter material over a number of other materials considered. The gamma ray efficiency of the detector was calibrated and found to be linear with gamma ray energy in the range from 663 keV to 7.73 MeV. The neutron sensitivity of the detector was also measured and found to be generally small compared to the gamma ray sensitivity. Preliminary neutron-capture cross section data in the upper electron volt range on gold indicates that the detector works well in this application. (auth)

**1572** (BNL-tr-88) ON THE FEASIBILITY OF USING GALLIUM AS A SOLAR NEUTRINO DETECTOR. Pomanskii, A. A. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). Translated by Stephen J. Amoretty (Brookhaven National Lab., Upton, N. Y.), from a report. 21p. Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $2.00 fs, $0.83 mf.

The study of the feasibility of gallium as a solar neutrino detector includes the problem of extracting germanium from gallium after the reaction $\nu + {}^{71}Ga \rightarrow {}^{71}Ge + e^{-}$ and the various background processes of $^{71}Ge$ formation. From the analysis it is evident that the use of gallium as a detector of solar neutrinos presents no serious difficulties. The most difficult problems are the development of a low background counter for the registration of the decay of radioactive germanium-71 and a total purification of germanium extracted from arsenic. (J.F.P.)

**1573** (NP-tr-1413) STUDY OF DIGITAL CONVERSION OF PHOTOGRAPHIC INFORMATION IN THE COLLEGE DE FRANCE HPD APPARATUS. Banasik, G.; Bloch, M.; Guignard, C. Translated by R. A. Slingo (Atomic Energy Research Establishment, Harwell, Eng.), from report FSD-66-1. 28p. Dep. mn. JCL $2.60 fs, $1.04 mf.

The HPD system is one that enables quick and accurate measurements of bubble chamber photographs. The principle of photograph measurement is described. The track center determination circuits are also described. (B.G.D.)

**1574** CHARACTERISTICS OF AN ALPHA PARTICLE POSITIVE POINT TO PLANE CORONA-STREAMER COUNTER IN AIR. Croucher, D. J.; Harrison, A. W. (Brighton Coll. of Tech., Sussex, Eng.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-13: No. 5, 22-4(Oct. 1966).

Operational alpha counting characteristics were obtained for a point-plane counter in air working in the corona-streamer mode. Hemispherically capped wires and rods were used as anodes having diameters 1.0 mm to 3.5 mm and spaced 0.6 cm to 2.0 cm from a flat polished tungsten cathode. (auth)

**1575** AN ELECTROMETER FOR USE IN SCIENTIFIC SPACE INSTRUMENTS. Josias, C.; Lawrence, J. Jr. (Analog Tech. Corp., Pasadena, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-13: No. 5, 25-36(Oct. 1966).

A wide-range vibrating-reed electrometer that obtained extensive detailed data on the "solar wind" during the Mariner II flight to Venus is described. This circuit used an inverting carrier-type dc amplifier with a logarithmic diode as its principal feedback element and represented the first successful application of a space-qualified dynamic capacitor electrometer. This system also represents one of the earliest all-semiconductor amplifiers to be used in a dynamic capacitor electrometer. The wide dynamic range of the application ($10^{-13}$ to $10^{-6}$ A) required the stabilization of a closed loop having 7 decades of continuous variation in the dynamic resistance of the primary feedback element. Some details of design, analysis, and performance associated with the electrometer amplifier and its feedback system are presented. (auth)

**1576** EXPERIENCE WITH ON-LINE BUBBLE CHAMBER MEASURING MACHINES. Gold, D. (Argonne National Lab., Ill); Yerkes, P.; Schweingruber, F. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-13: No. 5, 2-5(Oct. 1966).

About four-thousand events have now been measured at ANL using three measuring machines, each equipped with a small Recomp II computer. The computer has a 4K memory of 40 bit words and has floating point hardware. The computer guides and, in a sense, watches over the measurer, performing many elementary checks of the measuring process. A space reconstruction is not attempted, but sufficient checks are made to eliminate most mistakes and inaccuracies which would later cause failures during the reconstruction process. (auth)

**1577** CONSTRUCTION AND TESTING THE GEOMETRY OF A COSMIC RADIATION NEUTRON INTENSITY MONITOR OF STANDARD I.G.Y. DESIGN. Begum, Q. N.; Islam, M. S.; Hussain, M.; Mustafa, A. B. M. G.; Zaman, K. (Univ. of Dacca, Pakistan). J. Natur. Sci. Math., 6: 59-66(Apr. 1966).

A continuously operating cosmic radiation intensity monitor has been built here at Dacca ($\lambda$ geom. $\approx 12°N$ $\lambda$ geog. $= 23° 46' N$), according to the specifications given by the IUPAP. Before the pile was assembled following the standard design given by Simpson, one of the parameters determined by him, namely, the optimum moderator thickness was experimentally verified by us. The results agree with that of Simpson et al., within experimental error. The barometric coefficient of the data from this neutron monitor was calculated and found to be $(0.739 \pm .002)\%$ per mb. (auth)

**1578** CLOUD CHAMBER SEARCH FOR SUB-IONIZING PARTICLES. Haque, M. Bazlul (Univ. of Dacca, Pakistan). J. Natur. Sci. Math., 6: 41-58(Apr. 1966).

A further study for the search of relativistic sub-ionizing particles from external radioactive source was conducted with the help of a cloud chamber (Bearden chamber). The source strength used was of the order of 6-microcuries of radium. The sub-ionizing particles are classified as either free magnetic poles or relativistic charged particles. The limiting value of the sub-ionizer charge was assumed to be within $^{1}/_{2}$ to $^{1}/_{8}$ of the electronic charge. The chamber had a long sensitive time and the process of multiple photography per expansion was adopted. The basic factors for selecting those photographic records which may clearly indicate the presence of a sub-ionizing particle are emphasized. Five tracks were found to withstand all the tests and still looked quite suspicious, as though they might be due to sub-ionizers. The average number of drops per cm. of length was found to be 3.75 for one group of suspected tracks (averaged over three tracks), and 4.197 for the other group of tracks (averaged over two tracks). The distribution of ions along the path was subjected to Poisson's distribution and apparently they follow this distribution. Though it is not

possible to classify the suspected tracks as due to new particles, these tracks are different in that they have a droplet density less than one-tenth of that in tracks of the same photographs which seem to be due to the electrons. (auth)

**1579** THE EFFECT ON THE SCINTILLATION EFFICIENCY OF NaI(Tl) OF CHANGES IN THE THALLIUM CONCENTRATION AND STRAIN. II. THEORETICAL. Hill, R. (Borough Polytechnic, London). Brit. J. Appl. Phys., 17: 1385-93(Nov. 1966).

A theory is developed which relates the scintillation efficiency of single crystals of NaI(Tl) and the mean specific energy loss of the exciting particle. Consideration is given in the theory to the existence of two major luminescence processes, and this is found to affect significantly the scintillation efficiency at high specific energy loss. The major energy carriers are considered to be either electrons and self-trapped holes or excitons at low specific energy loss and photons resulting from the radiative decay of excitons at high specific energy loss. (auth)

**1580** THE EFFECT ON THE SCINTILLATION EFFICIENCY OF NaI(Tl) OF CHANGES IN THE THALLIUM CONCENTRATION AND STRAIN. I. EXPERIMENTAL. Hill, R.; Collinson, A. J. L. (Borough Polytechnic, London). Brit. J. Appl. Phys., 17: 1377-83(Nov. 1966).

The scintillation efficiency of a number of crystals of thallium-activated sodium iodide was measured. The crystals had thallium concentrations in the range 0.05 to 0.3% molar. The measured scintillation efficiencies of the crystals were compared with the values expected on the basis of the theory of Murray and Meyer, and consistent discrepancies were found. The effect of strain, both thermal and hydrostatic, on the scintillation efficiency was investigated, and the effects also found to be inconsistent with the theory of Murray and Meyer. (auth)

**1581** $\alpha$-SPECTROMETER. USING A GRIDDED ION CHAMBER. Naito, Minoru (Akita Univ., Japan). Mem. Fac. Liberal Arts Educ., Akita Univ., Natur. Sci., 1965: No. 15, 12-18(1965). (In Japanese).

An $\alpha$ spectrometer which is helpful for the radiometric studies of natural radioactive substances was constructed by using a gridded ion chamber with large collecting electrode as the detector of $\alpha$ particle and connecting it with a linear amplifier and a single channel pulse height analyzer of which details were previously reported. The characteristics and performance of this instrument were investigated by measuring the known $\alpha$ spectra of Po-210, U and Th prepared in the form of thin layers with a large area. For the energy resolution of the spectrum and the pulse height versus energy relation, a result adequate for practical use was obtained. (auth)

**1582** USE OF SEMICONDUCTOR DETECTORS FOR MEASUREMENT OF NEUTRON YIELD. Kim, Ki-Hyon; Bartl, Walter (Atomic Energy Research Inst., Seoul). Acta Phys. Austr., 23: 51-4(1966). (In German).

The neutron yield of a neutron generator at various acceleration voltages was measured using a semiconductor. The $\alpha$ radiation simultaneously emitted in the reaction $^3H(d,n)^4He$ was also measured with a semiconductor. The results were compared with those obtained with a conventional Long counter. The results showed an increase in the counting rate in the Long counter with respect to the $\alpha$ measurement. The origin of these discrepancies is discussed. (J.S.R.)

**1583** ELECTRON SCATTERING EFFECT IN THE SIEGBAHN-SLAETIS BETA SPECTROMETER. Semrad, D. (Technische Hochschule, Vienna). Acta Phys. Austr., 23: 209-14(1966). (In German).

The effects that scattering on the structural parts of the spectrometer has on the image size in the detector plane are considered. The measurement method is described. Upper limits for the electrons scattered in the detector should limit its effect on a falsification of measurement of continuous $\beta$ spectra. (tr-auth)

**1584** A SIMPLE APPARATUS FOR MEASUREMENT OF TRITIUM IN LIQUID SCINTILLATORS AND ITS USE FOR DETERMINING THE TRITIUM CONTENT OF AIR. Svoboda, R.; Cless-Bernert, T. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 194-8(1966). (In German).

A simple apparatus for the measurement of individual samples in liquid scintillators is described. With this device a detection sensitivity of up to 65% was obtained. The easy sample exchange and the good reproducibility of the measurement geometry makes the apparatus suitable for series of measurements. Methodical investigations of the tritium content in the atmosphere were carried out with this device. (tr-auth)

**1585** MULTIPLE-COUNTER ADDITION FOR A TMC MULTICHANNEL INSTRUMENT. Attwenger, W.; Fischer, O. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 377-81(1966). (In German).

In many nuclear physics experiments it is necessary to use several counters with the same dead time. A multichannel instrument can be used as a multiple counter when the pulses of a given counting channel are stored under one address in the instrument and a dead time independent of the address is arranged. If, however, within a short testing time (200 nsec) pulses are fed to two or more counting channels, these were eliminated. The block diagram of a multicounter addition was described in which the first 16 channels of a TMC multichannel CN 110 analyzer was used as the counter. (tr-auth)

**1586** SURFACE BARRIER DETECTORS OF GALLIUM ARSENIDE. Schuster, P.; Getoff, N. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 387-92(1966). (In German).

The preparation of surface-barrier detectors of gallium arsenide is described. Measurements made with the detector show that good surface-barrier detectors can be prepared from gallium arsenide as long as a material with mean specific resistance and high charge carrier lifetime is available. (J.S.R.)

**1587** PRODUCTION OF COUNTER DIODES ACCORDING TO THE LITHIUM-DRIFT METHOD. Braun, H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 393-6(1966). (In German).

A method for the preparation of $\beta$ counters from Si using the Li drift method is described. Because of the low cost the apparatus is especially suitable for laboratory applications. The principle of the Li drift method is given. (J.S.R.)

**1588** INVESTIGATION OF THE STABILITY OF THE COUNTER EFFICIENCY OF GEIGER-MUELLER TUBES. Lang, D. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 400-3(1966). (In German).

The consistency of the efficiency of Geiger–Mueller tubes (Philips types 18503, 18504, 18509, and 18529) over periods of more than a year and a half was investigated. The accumulated pulse numbers were $2 \times 10^8$ up to $7 \times 10^9$ according to the type. Four of the six tested counters displayed an oscillation of $\pm 1.5\%$ at a maximum with consideration of the activity decrease and one a maximum of $\pm 3.5\%$. The statistical error was $\pm 0.3\%$. The oscillations can be explained by modification of the backscattering behavior in the vicinity of the research apparatus. The sixth counter showed additional pulses after approximately $7 \times 10^7$ accumulated pulses. (tr-auth)

**1589** NULL-PASS TRIGGER AS TIME-SCALE INDICATOR FOR COINCIDENCE MEASUREMENTS. Halling, H.; May, F. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 404-6(1966). (In German).

A circuit for scintillation pulses was constructed which assigned a time scale to the pulses in a broad amplitude range. The circuit works by the 0-pass trigger principle in which a tunnel diode is used as the active element. The tunnel diode remains closed when the input pulse is not within a given amplitude range determined by a single channel. (tr-auth)

**1590** IONIZATION CALORIMETER FOR STUDYING HIGH ENERGY COSMIC MUONS AT LARGE ZENITH ANGLES. Borog, V. V.; Kirillov-Ugryumov, V. G.; Petrukhin, A. A.; Rozental, I. L.; Shestakov, V. V. pp 59-68 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

An ionization calorimeter for studying high-energy cosmic muons is described. The system consists of 150 ionization chambers interspersed in six rows and a coordinate generating network for determining the angle of shower penetration. A block diagram of the whole system, as well as a circuit diagram for the amplifier, are given. Some of the proposed experiments are outlined. (G.O.Y.)

**1591** STREAMER CHAMBER. Aleksanyan, A. S.; Bobrov, V. D.; Butikov, Yu. A.; Dolgoshein, V. A.; Luchkov, V. I.; Rodionov, B. U.; Rudenko, N. S. pp 69-75 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

A streamer chamber is described for detecting cosmic elementary particles. The chamber is contained in a glass box measuring $160 \times 100 \times 600$ mm$^3$. The streamer chamber contains a gas (Ar, He, Ne, Xe, and mixtures of these) in the 160 mm gap between the two electrodes. A high voltage pulse analyzer, a power pulse generator, a camera, and a coincidence circuit used along with the streamer chamber are also described. Some pictures of cosmic particles taken with the streamer chamber camera are given. (G.O.Y.)

**1592** BUBBLE CHAMBER OPERATING IN MAGNETIC FIELD. Alikhanyan, A. I.; Aleksanyan, A. S.; Verebryusov, V. S.; Veremeev, M. M.; Demidov, V. S.; Kirillov-Ugryumov, B. G.; Protasov, V. P.; Ponosov, A. K.; Sergeev, F. M. pp 76-82 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

A bubble chamber with a 200 liter volume designed for operation in a magnetic field is described. The chamber is equipped with a movable photographic window and fast photographic equipment. The bubble chamber was used for runs with various liquids: propane, a mixture of freon-12 and -13, a propane-freon mixture, and with propane-ethane-freon. (G.O.Y.)

**1593** STATISTICAL ERROR IN DETERMINING THE RATE OF RADIOACTIVE DECAY BY MEANS OF A MULTICHANNEL TIME ANALYZER. Grashin, Yu. M. pp 87-95 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The method of least squares is applied to Peierls' formula in order to derive an algorithm for determining the statistical error in measurements of radioactive decay using a multichannel analyzer. (G.O.Y.)

**1594** ELECTRON PULSE SHAPE IN A RECTANGULAR CYLINDRICAL IK-6 IONIZATION CHAMBER. Petrukhin, A. A. pp 96-9 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The shape of a 36 μsec electron pulse was studied in an IK-6 ionization chamber at 5 atmospheres using a voltage of 1200 V. The current and the power were analyzed as functions of the duration of the pulse. (G.O.Y.)

**1595** HURST-TYPE PROPORTIONAL COUNTER WITH DIGITAL EQUIPMENT FOR THE EVALUATION OF ABSOLUTE DOSE OF FAST NEUTRONS. Biri, Janos; Deme, Sandor. Magyar Tud. Akad. Kozp. Fiz. Kut. Inst. Kozlem., 14: 311-24(1966). (In Hungarian).

The conditions for the measurement of the absolute dose of fast neutrons in tissues are investigated, and the design and performance characteristics of a Hurst-type proportional counter are discussed. The digital pulse amplitude integrator developed and used in conjunction with the counter is described in detail. Finally the possible applications of the equipment are considered. (auth)

**1596** PARTICLE MOTION IN A RETARDING MEDIUM IN A HOMOGENEOUS MAGNETIC FIELD AND PROCESSING OF THE DATA OBTAINED WITH A BUBBLE CHAMBER. Krotov, V. V.; Sherman, S. G. (Inst. of Physics and Tech., Leningrad). Prib. Tekh. Eksp., No. 3, 31-4(May-June 1966). (In Russian).

Precise solutions of the relativistic equation of the motion of charged particles in homogeneous magnetic fields in the presence of a homogeneous retarding medium were given. It was shown how to use this equation for the determination of the original particle momentum in the chamber in the presence of non-homogeneous magnetic fields, both for reprojection programs and for automatic programs. (tr-auth)

**1597** ELECTRONIC INSTRUMENTATION OF A BUBBLE CHAMBER WITH PULSED MAGNETIC FIELD. Baranov, V. I.; Shlyapnikov, R. S. (Inst. of Nuclear Power, Moscow). Prib. Tekh. Eksp., No. 3, 44-50(May-June 1966). (In Russian).

The electronic instrumentation of the bubble chamber with pulsed field is described. It consists of (1) section for the synchronization of the operation of the device, (2) section for the selection of the operational mode, and (3) section for the output switch for the ejection of particles by the accelerator. A thorough check of the electronic systems during use showed its reliability. (tr-auth)

**1598** PRECISION OF THE RECONSTRUCTION OF PARTICLE TRAJECTORIES IN A SPARK CHAMBER. Bayukov, Yu. D.; Zaitsev, Yu. M.; Leksin, G. A.; Sokolova, L. N. (Inst. of Theoretical and Experimental Physics, Moscow). Prib. Tekh. Eksp., No. 3, 51-4(May-June 1966). (In Russian).

The dependence of the precision of the reconstruction of particle trajectories from the position of the point at the spark in the spark chamber, across which extrapolation lines were traced, was investigated. It was shown that the position of the point that is the least distant from the particle trajectory — the rectification point — depends on the operational conditions of the bubble chamber and is practically the same for particles crossing the chamber under different angles. It was found that the mean-square deviation at the p point close to the rectification point is 0.2 mm for particles crossing the chamber perpendicularly with electrons. It was proved that the straight lines, obtained by the method of least squares across a given point of the spark, at the precision limits of the experiments actually represent the particle tracks. (tr-auth)

**1599** DISTORTIONS AND SPURIOUS SCATTERINGS IN NUCLEAR EMULSIONS. Gaitinov, A. Sh., Izbasarov, M.; Streltsov, I. S.; Takibaev, Zh. S.; Chasnikov, I. Ya. (Inst. of Nuclear Physics, Alma-Ata, USSR). Prib. Tekh. Eksp., No. 3, 54-9(May-June 1966). (In Russian).

The results of the measurement of multiple Coulomb scatterings on the tracks of protons with energies of 3, 5, and 10 GeV in NIKFI-R emulsions exposed at the JINR and on primary meson ($\pi$) tracks and tracks of secondary particles from $\pi$-N interactions at 17 GeV in Ilford G-5 emulsions exposed at CERN, were reported. The dependence of the distortion and spurious scatterings on the angle of immersion of the track was investigated as a function of emulsion density. It was shown that the size of the distortion very strongly depends on the angle of the immersion of the track, and the spurious scatterings depend very slightly on it. The boundary conditions of the reliability of the energy determination were found. (tr-auth)

**1600** DETECTION OF SINGLY CHARGED PARTICLES IN NUCLEAR EMULSION BY MEASURING THE RESIDUAL RANGE AND IONIZATION. Skirda, N. V. Prib. Tekh. Eksp., No. 3, 59-62(May-June 1966). (In Russian).

The permissible power (discrimination capacity D) of the method of identification of singly-charged particles based on the measurement of the ionization and residual range, was examined. The mathematical expressions for D were given and it was shown how the values, D, for particles of different mass can be found by use of the track of single particles. A simple method of determining D for particles with charge Z = 2 (by measurement of the ionization on the track of singly charged particles) was described. (tr-auth)

**1601** ANALYSIS OF AFTERPULSES IN $CO_2$ COUNTERS. Karasik, A. S. (Perm State Univ., USSR). Prib. Tekh. Eksp., No. 3, 63-6(May-June 1966). (In Russian).

The results of the investigation of the time distribution of the afterpulses in $CO_2$ counters were reported. The method for the analysis of the afterpulses in Geiger counters was discussed. It was shown that the most probable reason for the afterpulses in the $CO_2$ counters is either the metastable state of the $CO_2$ or the negative ions formed in the primary discharge. (tr-auth)

**1602** WATER-SOLUBLE EPOXY ADHESIVE COMPOUND FOR SCINTILLATION COUNTERS. Aleksandrov, Yu. A.; Kutsenko, A. V.; Maikov, V. N.; Pavlovskaya, V. V. (Inst. of Physics, Moscow). Prib. Tekh. Eksp., No. 3, 221-2(May-June 1966). (In Russian).

The results of some preliminary experiments using glycerin-diethylene glycerol and ethylene diamine as adhesives in various scintillation counters are briefly discussed. It was found that use of these water-soluble epoxy adhesives compares favorably with the use of plastics. (G.O.Y.)

**1603** LOW BACKGROUND GAS-FILLED ELECTRON AND X-RAY COUNTERS. (REVIEW). Kocharov, G. E.; Naidenov, V. O. (Inst. of Physics and Tech., Leningrad). Prib. Tekh. Eksp., No. 3, 5-18(May-June 1966). (In Russian).

A review is given of the contemporary methods for the construction of gas-filled counters with low-background levels. The basic characteristics of the effective low background devices are described. It was shown that the lowest background is obtained by use of small proportional counters. (tr-auth)

**1604** X-RAY DIFFRACTOMETER WITH IONIZATION CHAMBER. Alekseev, S. I.; Karpukhin, V. I.; Nikolaenko, V. A. (Inst. of Nuclear Power, Moscow). Prib. Tekh. Eksp., No. 3, 202-5(May-June 1966). (In Russian).

The ionization chamber, used as an x-ray detector in the URS-50-I diffractometer, was described. The layout of the electrometric amplifier is described. The x-ray pictures, characteristic of the work of the installation, are presented. (tr-auth)

**1605** RECORDING OF X RADIATION USING SEMICONDUCTOR LAYERS WITH HIGH-VOLTAGE PHOTOELECTROMOTIVE FORCE. Tsukerman, V. G.; Vainshtein, E. E.; Lyubin, V. M. (Inst. of Inorganic Chemistry, Novosibirsk, USSR). Prib. Tekh. Eksp., No. 3, 205-7(May-June 1966). (In Russian).

The effect of ionizing radiation (particularly x radiation) on the size of the hf photoelectromotive force of a series of semiconductor layers was investigated. The effect of the nature of the surrounding gas and of the intensity of the x ray and visual light on the sensitivity of the layer to radiation was established. The time for the attainment of stationary values of the photoelectromotive force does not exceed a tenth of a second. (tr-auth)

**1606** RESOLUTION OF A SPARK IMAGING CAMERA (SPINTHARICON) WITH PARALLEL CHANNEL COLLIMATORS. For-

saith, Ann L.; Horwitz, N. H.; Lofstrom, J. E. (William Beaumont Hospital, Royal Oak, Mich.). Phys. Med. Biol., 11: 411-22 (1966).

The results of resolution measurements performed on a spark imaging camera are presented. The minimum separation distance is shown to be essentially defined by the collimator design. Excellent images of a hexagonally shaped phantom are obtained with the spark camera and these are compared with scintiscans of the same phantom. The spark camera exhibits a resolution superior to that obtainable with scintillation line scanners. Early work in which the spark camera was applied to radiography with microcurie sources is described. (auth)

**1607** NEW METHOD TO UNFOLD PULSE-HEIGHT DISTRIBUTION. Su, Yung Sung; Shih, Shy Min (National Tsing Hua Univ., Taiwan, China). Chin. J. Phys. (Taiwan), 4: 27-31(Apr. 1966).

A method to unfold pulse-height distribution obtained from scintillation spectrometer into energy spectrum is proposed. The proposed method is a modification of the Scofield's iteration method. By utilizing IBM-1620 digital computer, it is found that the proposed method can save more than one third of computing time and give a better result. (auth)

**1608** FUNCTIONING MODEL OF THE SOFT X-RAY SLITLESS SPECTROMETER. Zehnpfennig, T. (American Science and Engineering, Inc., Cambridge, Mass.). Appl. Opt., 5: 1855-6 (Nov. 1966).

The fabrication of a working model of the soft x-ray slitless spectrometer, consisting of a grazing incidence x-ray telescope (the entrance aperture of which is covered by an x-ray transmission grating) and of a detector such as photographic film placed in the focal plane of the telescope, is described. Intended for applications in the field of soft x-ray astronomy, it is capable of producing high resolution data concerning the spectral and spatial distribution of 2-Å to 10-Å emission from sources such as solar flares. The operation is similar to that of slitless spectrometers used in the visible region. Data on its performance in the laboratory are presented. (W.D.M.)

**1609** DETECTION EFFICIENCY OF BARE AND MODERATED $BF_3$-GAS-FILLED PROPORTIONAL COUNTERS FOR ISOTROPIC NEUTRON FLUXES. Yamashita, Mikio (Electrotechnical Lab., Tokyo); Stephens, Lloyd D. J. Nucl. Sci. Technol. (Tokyo), 3: 343-53(Aug. 1966). (UCRL-16103).

An elaborate calibration of $BF_3$-gas-filled proportional counters with and without a moderator was made for isotropic neutron fluxes. The effective sensitivity of a bare $BF_3$ counter in a nondiffusing medium was determined by means of a calibrated indium foil. The flux depression effect in a diffusing medium was experimentally evaluated. Details of the experimental techniques and results are described. For the measurement of fast neutrons, energy dependence of sensitivity of two differently moderated counters was determined in the energy region from 1 eV to 10 MeV. Angular dependence of sensitivity of the moderated counters and its dependence on neutron energy are also described. (auth)

**1610** PORTABLE COMPACT $\gamma$-RAY SPECTROMETER AMA-6. Trifonov, V. V.; Pegoev, A. N. Byull. Tekh.-Ekon. Inform. Gos. Nauch.-Issled. Inst., 18: No. 10, 31-2(1965). (In Russian).

The compact gamma spectrometer AMA-6 which is portable, completely transistorized, and has a magnetostrictive memory is described. The specifications of the spectrometer are a channel capacity of 65,535 impulses, highest recording frequency of 500 impulses/sec, highest input load 8,000 impulses/sec, and automatic exposure time of 265 or 530 seconds. Also the spectrometer has an operating voltage of 12 to 14 volts, a power consumption of 10 W, and an operating range of 0 to 40°. (J.F.P.)

**1611** MEASUREMENT OF CHARGED PARTICLE SPECTRA AT SMALL ANGLES. Klyucharev, A. P.; Titov, Yu. I. (Kharkov State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 229-31(Feb. 1966). (In Russian).

An electronic device that facilitates detection and measurement of the energies of charged particles against a high background of lower-energy particles is described. The device was developed in connection with an investigation of the $\alpha$ particles from the $^{13}C(d,\alpha)^{11}B$ reaction against the background of elastically scattered deuterons. The difficulty arises from superposition of several background pulses to form a single pulse that can pass the discriminator. The idea of the described technique is immediately to shorten the pulses by differentiation, to discriminate against the background pulses while the pulses are short, and subsequently to stretch the pulses to that they can operate a commercial pulse-height analyzer. In the experiments with the $^{13}C(d,\alpha)^{11}B$ reaction, the pulse length at the discriminator was 0.2 microsec. The significant features of the discriminator and pulse stretcher unit were the use of a type D101 silicon point diode as discriminator and the use of a thermionic diode, rather than a crystal diode, in the pulse-stretcher stage. The discriminator diode, whose capacity (with a 10-v back bias) was only 0.5 pF, was very stable in operation. A silicon diode proved unsuitable for use in the pulse stretcher stage, however, because passage of a 10-mamp forward current greatly reduced its back resistance, which did not recover until after 0.5 microsec. (ATD)

**1612** SCINTILLATION SPECTROMETER WITH CHARGED-PARTICLE DISCRIMINATION. Mikhaleva, T. N.; Zazulin, V. S.; Chuprunov, D. L.; Titov, V. I. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 343-8(Feb. 1966). (In Russian).

A scintillation spectrometer using a single CsI(Tl) crystal and a single photomultiplier with which pulses due to $\alpha$ rays, protons, and $\alpha$ particles can be distinguished, identified, and recorded in different channels of a multichannel pulse analyzer, depending on the energies of the particles producing them is described. The technique for identifying the particles is based on the fact that the current pulse on a dynode of the photomultiplier has the form of a decreasing exponential, of which the time constant depends on the nature of the particle producing the pulse. An electronic circuit for performing the identification is described in some detail. With the described circuit it is possible simultaneously to record $\alpha$ particles, protons, and $\gamma$ rays, to record only $\alpha$ particles and protons in the presence of a $\gamma$ background, or to record only $\alpha$ particles in the presence of protons and $\gamma$ rays, and to accumulate the pulses in different channels of a pulse height analyzer depending on the energies of the particles. When several kinds of particles are recorded simultaneously, however, a single channel of the analyzer corresponds to different energies for the different kinds of particles. The instrument was tested by recording the $\alpha$ particles, protons, and $\gamma$ rays from an aluminum target bombarded with 6.6-MeV protons; and the recorded spectra, as well as discrimination curves, are presented. (ATD)

**1613** BETA-GAMMA COINCIDENCE SCINTILLATION SPECTROMETER WITH A LOW GAMMA-GAMMA COINCIDENCE BACKGROUND. Kraft, O. E.; Naumov, Yu. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2141-6(Dec. 1965). (In Russian).

A beta-gamma coincidence scintillation spectrometer is described in which means are employed to reduce the gamma-gamma coincidence background. Such means are particularly desirable when investigating complex decay schemes where there are many gamma cascades. In this spectrometer the gamma rays are detected with an NaI crystal and the beta particles with an anthracene crystal or a plastic scintillator. Between the source and the beta detector is mounted a thin (~0.3 mm) film of plastic scintillating material in a highly reflecting housing of ~1 $\mu$ aluminum foil. The photomultipliers associated with the beta detector and the film scintillator are connected to a coincidence circuit, and only coincidences are recorded as beta particles. Gamma rays that enter the beta detector can not produce a flash in the thin-film scintillator and thus are not recorded. The energy lost by a beta particle traversing the film scintillator and its housing was found to be 80 to 100 keV; this energy loss makes the instrument unsuitable for the investigation of soft beta spectra. The behavior of the instrument is discussed in some detail, and it is concluded that in cases favorable to its use the gamma-gamma coincidence background can be reduced by a factor of 10 to 20 without serious reduction in the true beta-gamma coincidence counting rate. The instrument was employed to record the spectrum of gamma rays in coincidence with positrons of the 1500-keV end-pont component of the beta spectrum of $^{146}Eu$. The source was the gadolinium fraction separated chromatographically from a tantalum target bombarded with 600-MeV protons and aged for two or three months. After aging, the material consisted almost entirely of $^{146}Gd$ and the $^{146}Eu$ in equilibrium with it. In the gamma spectrum there were found two approximately equal peaks corresponding to gamma energies of 635 and 745 keV. It is concluded that the 1500-keV end-point beta decay goes to the 1380-keV level in $^{146}Sm$. In these measurements the gamma-gamma coincidence background did not exceed 10% of the true beta-gamma coincidence counting rate. When the film scintillator was removed the gamma-gamma coincidence counting rate was approximately equal to the true beta-gamma coincidence rate. It is concluded that the use of the film scintillator in coincidence with the beta detector reduced the gamma-gamma coincidence background by a factor between 10 and 20. (ATD)

**1614** MAGNETIC $\beta\gamma$ COINCIDENCE SPECTROMETER. Dzhelepov, B. S.; Kraft, O. E.; Naumov, Yu. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2163-7(Dec. 1965). (In Russian).

A spectrometer that was developed for studies of gamma coincidences with low-intensity hard components of beta spectra is described. (D.C.W.)

**1615** DUPLEXED TOROIDAL $\beta$ SPECTROMETER FOR STUDYING e-e AND $\beta$-e COINCIDENCES. Dzhelepov, B. S.; Prikhodtseva, V. P.; Tishkin, P. A.; Shishelov, I. A. (Leningrad State Univ. Radium Inst., Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2157-62(Dec. 1965). (In Russian)

A duplexed toroidal beta spectrometer that was developed for studies of decay schemes by the coincidence technique is described. (D.C.W.)

**1616** THE EFFICIENCY DEPENDENCE OF GEIGER-MUELLER TUBES ON THE ANGLE OF INCIDENCE OF GAMMA RADIATION. Kulka, Milan; Holecek, Milan. Cesk. Cas. Fys., 16: 529-33(1966). (In Czech).

The dependence of the frequency of pulses registered by a Geiger-Müller tube at various angles of incidence of gamma radiation is discussed. As a first approximation for the dependence of frequency of pulses registered by GMT in a broad parallel beam of gamma radiation the expression $N_{par} = J\eta$ is proposed in which J is the gamma radiation intensity at the tube and $\eta$ is a constant dependent on the design of the tube and on the gamma radiation energy, but independent of the angle of incidence of gamma radiation upon the tube. This expression is discussed and comparison with experimental data made. (auth)

**1617** DEVELOPMENT OF A BALLOON-BORNE CHARGE-DISCRIMINATING COSMIC-RAY TELESCOPE. Parnell, Thomas Alfred. Chapel Hill, N. C., Univ. of North Carolina, 1965. 84p.

Thesis.

A system of detectors has been investigated to measure the charge of the primary cosmic rays above 2.6 BeV/nucleon. The system consists of a gas Cherenkov detector to define a minimum detection energy, a scintillation crystal to measure the charge, and other detectors for collimation and shower rejection. An instrument consisting of these devices and equipment for analyzing and recording the data has been constructed and flown to 125,000 ft on a balloon to observe the primary cosmic radiation. The results of the balloon flights indicate that when modifications of the shower detector are made, the instrument will produce accurate data on the abundances of the hydrogen and helium components of the primaries. (Dissertation Abstr.)

**1618** KERNPHYSIKALISCHE MESSVERFAHREN ZUM NACHWEIS FUER TEILCHEN UND QUANTEN. (Nuclear Physics Measuring Methods for the Detection of Particles and Quanta). Neuert, Hugo. Karlsruhe, Ger., Verlag G. Braun, 1966. 542p.

A detailed description is given of the different types of detectors used in the study of radioactivity, cosmic radiation, physics of subatomic particles, and x rays. Their technical construction and uses are discussed. The radiation detection instruments considered are ionization chambers, proportional counters, emitting counters, spark counters and chambers, Cherenkov counters, scintillation counters, semiconductor counters, detectors for special purposes, and neutron counters. Counting statistics and counter circuits are also discussed. An extensive bibliography follows each subject. (J.S.R.)

**1619** DELAYED COINCIDENCE METHOD FOR STUDYING FAST LIGHT PULSES. Sjoelin, P. -G. (Aktiebolaget Atomenergi, Studsvik, Sweden). 8p. (CONF-650676-1). ORAU.

From Conference of the Swedish National Committee for Physics, Uppsala.

A delayed coincidence method for studying fast light pulses will be described. The method is closely related to those of Bollinger and Thomas and of Koechlin, but offers some experimental simplifications. The apparatus has been used to determine the scintillation decay characteristics of some fast organic scintillators. The time-to-pulse height converter which is included in the apparatus is of the Green and Bell type and covers a time interval of approximately 100 ns. The method offers a convenient way to study the time behavior of fast light pulses with a rather high time resolution and good statistical accuracy. (auth)

**1620** PORTABLE INSTRUMENTS FOR THE MEASUREMENT OF NEUTRON DOSE EQUIVALENT RATE IN STEADY STATE AND PULSED NEUTRON FIELDS. Leake, J. W. (Atomic Energy Research Establishment, Harwell, Eng.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/3, 18p. (CONF-660807-23). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

Two portable monitors are described which enable the dose equivalent rate to be measured for neutrons of any energy between thermal and 12 MeV, in both pulsed and steady radiation fields. The first instrument comprises an 8.2" (20.8 cm) diameter sphere with integral portable electronics and has a total weight, including batteries, of 14 lb (6.4 kg). The detector is a development of the Andersson-Braun counter and consists of a double polythene moderator system, separated by a cadmium shield, with a lithium iodide (europium-activated) crystal at the center which is viewed by a photomultiplier. The neutron energy response of the detector matches the recommendations of the ICRP (1963) within ±50% for neutrons with energies between 200 KeV and 10 MeV, the sensitivity falling above 10 MeV. Below 200 KeV the sensitivity increases above the required value to a maximum at 5 KeV where it overestimates by a factor of 3½ times. At thermal energies the response is high by a factor of 3¼ times. Neutron d.e. rate is displayed on a 5" long scale marked with 3½ decades, 0.5 to 1000 m rem/h. The gamma sensitivity of the monitor is such that 1R/hr of $^{60}$Co radiation produces a response that is less than 1 m rem/h. This monitor has not been designed specifically for use in pulsed radiation fields, but it may be so used up to N m rem/h, where N is the frequency (p.p.s.) of the radiation, with less than 26% count losses by taking advantage of the slowing-down and diffusion times of the neutrons in the polythene moderator. The second instrument described was designed for use around pulsed radiation sources, especially those which operate at a low prf, and provides indication of neutron d.e. rate from 1 to 3000 m rem/h on 3 switched linear ranges. The neutron detector in this case is an Andersson-Braun type moderator assembly fitted with a mean current $^{10}BF_3$ filled ion chamber. The neutron energy response is such that the ion chamber current is proportional (within ±50%) to the neutron dose equivalent rate for neutrons of all energies from thermal to 12 MeV. The gamma sensitivity is such that 4 mR/h of $^{60}$Co radiation produces a response equivalent to 1 m rem/h. In many cases the gamma sensitivity can be neglected or a correction can be readily applied by the use of a separate gamma monitor. The total weight of this monitor is 25 lb (11 kg). (auth)

**1621** INTERNAL LIQUID SCINTILLATION COUNTING APPLIED TO THE ABSOLUTE DISINTEGRATION-RATE MEASUREMENT OF ELECTRON-CAPTURE NUCLIDES. Steyn, J. (Council for Scientific and Industrial Research, Pretoria). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/16, 16p. (CONF-661012-25). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

The nuclides chromium-51, manganese-54, cobalt-57, cobalt-58, and zinc-65 were standardized by counting of coincident radiation with an internal liquid scintillation counter containing the source in solution, and a sodium iodide gamma scintillation counter. Coincidence measurements were made at different values of x-ray-plus-Auger electron counting efficiency. This variation of counting efficiency was obtained electronically by varying the amplification and/or the discrimination level. It is shown how a graph of x-ray-plus-Auger counting rate against the ratio C/G, where C and G are the coincidence and gamma counting rates respectively, is a straight line which can be extrapolated accurately to give the disintegration rate of the source. This extrapolation corrects for complications caused by the gamma-ray contribution in the liquid scintillation detector. The standardization results were compared with coincidence counting of deposited sources in a conventional $4\pi$ proportional counter-gamma counter coincidence arrangement. The nuclides chromium-51, manganese-54, cobalt-58 and zinc-65 were further used to establish a graph of counting efficiency against characteristic energy. This could then be used to find the counting efficiency of the liquid scintillation counter for the pure electron capturing nuclide iron-55, and thus the disintegration rates of sources of this nuclide. The method demands that sources of the above-mentioned nuclides be counted at least once under identical experimental conditions. After the characteristic curve was obtained, however, it is only necessary to count a sample of any one of the above gamma-emitting nuclides together with the iron-55 either as internal or external standard to obtain the disintegration rate of the iron-55 sample. Results are presented, illustrating the degree of precision and reproducibility obtained. (auth)

**1622** HIGH-SENSITIVITY ADIABATIC GAMMA CALORIMETER. Kholnova, R. A.; Kulkova, L. P. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/70, 16p. (In Russian). (CONF-661012-14). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

The design of a high-sensitivity adiabatic gamma calorimeter is described and results obtained with it are presented. The calorimeter consists of a spherical lead absorber (diameter 70 mm) in a waterproof brass chamber. The source which is to be measured is introduced via a vertical channel into the spherical absorber without disturbing the initial temperature conditions of the system as a whole. Changes in the temperature of the absorber, caused by its absorbing radiation from the source, are measured by two thermis-

tors mounted in the absorber and a platinum resistance thermometer. From the rate at which the resistance of the thermistors or of the platinum thermometer varies it is easy to determine the energy released in the calorimeter of the source, provided that the calorimeter is first calibrated in watts by means of a heat source of known power. A suitable heat source for this purpose is a heating spiral mounted in the spherical absorber; its resistance and the intensity of the current passing through it are measured with a high degree of accuracy by means of a potentiometer device. The calorimeter operates under adiabatic conditions. The chamber with the calorimeter is set up in the center of a water thermostat whose temperature increases in step with the heating of the calorimeter; this is achieved by means of two heat-regulating systems. The first system, consisting of contact thermometer, relay and several heaters at different points in the bath, maintains the necessary temperature to within ±0.01°C. The second system, which incorporates a thermopile consisting of 50 thermocouples, sensitive galvanometer, photoelement, amplifier and a number of heaters, ensures the fine regulation of the adiabatic regime, so that the maximum temperature difference between the calorimeter and the thermostat does not exceed 0.0002°C. The sensitivity of the calorimeter, found as a consequence of calibration from measurements with the thermistors, is $1.84 \times 10^{-3}$ W/ohm/h, which is sufficient for the measurement of different gamma sources with an energy release of the order of $10^{-4}$ W (for $^{60}$Co sources this is approximately 5 Ci). The maximum error involved in the measurement of such gamma sources does not exceed 2.5–3%. An adiabatic calorimeter of a similar type has been described by Maiers; however, the calorimeter described differs in a number of significant respects. For example, the absorber is in the form of a fairly small sphere, which has a considerable effect on its sensitivity. The absorption of gamma radiation of different energies in a lead sphere of such dimensions was calculated earlier and the results used in the present work. (auth)

**1623** APPLICATION OF LOW GEOMETRY COINCIDENCE METHODS IN MEASUREMENTS OF DISINTEGRATION RATES. Kowalski, E.; Binkert, T.; Siegenthaler, R.; Meyer, K. P. (Univ., Bern). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/14, 12p. (CONF-661012-15). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

The results of investigations on coincidence methods employing scintillation counters with small solid angles and efficiencies different from one will be reported. Two single radiations or two groups of radiations can be used in this coincidence measurement. The counter responses to both radiations or radiation groups must be made approximately equal. Due to the low geometry of the used detectors, the effects of sum-event pulses, angular correlation of the coinciding radiations, coincidences by scattering and coincidences between radiations belonging to the same radiation group must be considered. The $\gamma$-$\gamma$, x-$\gamma$ or x-x measurements offer advantages in calibration of sources with doubtful radiochemical purity if the coinciding radiations are selected in a correct manner. Another interesting application is to measure the source strength of radioactive solutions filled in glass ampoules without opening them. Neutron-activated foils can also be calibrated directly, without the previous preparation of a solution and a weight-less source. Cascades of highly converted $\gamma$-rays can be measured by means of an x-x coincidence method. Of course the low geometry coincidence measurements can also be done by the use of particle radiations. The main limitations of the methods quoted lie in the very long time required for one measurement and in the sensitivity of the method to coincidences by scattering. The elimination of coincidences by scattering becomes difficult if hard $\gamma$-rays are present in the measurement for which the pair-production probability is high. The main value of the low geometry coincidence methods lies in the possibility of cross-check with some other calibration methods or auxiliary techniques (e.g., to test the dilution accuracy) by means of an independent absolute measurement, rather than in making routine measurements on great quantities of sources. (auth)

**1624** CALIBRATION OF REFERENCE GAMMA SOURCES. Karavaev, F. M.; Yudin, M. F. (Mendeleev All-Union Scientific Research Inst. of Metrology, Leningrad). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/68A, 16p. (In Russian). (CONF-661012-13). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

A system of calibrating reference gamma sources is described. With this system of calibration two basic characteristics are measured: the activity of the nuclide in the source, and the exposure dose rate at 1 m from the center of the source placed in a standard collimator. The superiority of this calibration system is demonstrated. The activity of reference gamma sources is measured by means of measuring assemblies that incorporate calorimeters or ionization chambers. The following equipment is used in calibrating reference gamma sources according to the exposure dose rate: an assembly incorporating a standard ionization chamber filled with air at above atmospheric pressure (for calibrating gamma sources certified as working standards), or assemblies with ionization chambers and scintillation counters (for calibrating reference and working gamma sources by comparing them with a reference source with a higher level of discharge). Experimental values, determined during calibration, for the relationship between the activity and exposure dose rate of $^{60}$Co and $^{137}$Cs reference gamma sources are presented. (auth)

**1625** METHODS OF MEASURING HIGH-ACTIVITY RADIATION SOURCES. Forafontov, M. V.; Vukolov, Yu. N.; Kodyukov, V. M.; Ostretsov, L. A.; Nesterova, V. V.; Polyakov, L. N.; Sokolov, A. I.; Fradkin, G. M. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/72, 16p. (In Russian). (CONF-661012-9). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

A method of measuring high-activity radiation sources is described and experimental data are presented on activity measurements for a number of isotopes. The activity of gamma sources is measured by taking the intensity of the hardest gamma line in the spectrum of the isotope being investigated. With this method the gamma source is separated by shielding (e.g., a container) from the detector and the operator; this is particularly important in high-activity gamma source measurements. The method is extremely rapid and no additional shielding is necessary for ensuring the safety of the operating personnel. In addition, a calorimetric method of determining the activity of powerful gamma and beta sources is described. (auth)

**1626** LEAST SQUARES POLYNOMIAL FITTING OF COINCIDENCE COUNTING DATA FOR THE EVALUATION OF ABSOLUTE DISINTEGRATION RATES. Adams, R. J.; Baerg, A. P. (National Research Council, Ottawa). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/25, 6p. (CONF-661012-6). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

In the general coincidence formulas used to determine the absolute decay rate by $4\pi\beta$-$\gamma$ coincident methods $N_\beta = N_0\, F(N_c/N_\gamma)$ and $N_\beta N_\gamma/N_c = N_0\, G(N_\gamma/N_c)$. The functions F and G can be found experimentally by suitable variation of the beta detector efficiency. In order to determine $N_0$ therefore, it is necessary to fit an $n^{th}$ order polynomial to the data, since, although these functions are often approximately linear, in general this is not the case. As a least squares fitting criterion is employed it is necessary that the order of the function be determined and that the deviations of the data about the final regression curve are randomly distributed. The order is found by calculating that polynomial about which the observations are distributed to a degree consistent with the precision of the measurements (using $x^2$ test for goodness of fit). A set of N observations ($y_1$, $x_1$, $y_2$, $x_2$ ... $y_N$, $x_N$) yields a polynomial experimentally defined as $y_i = f(x_i, a, b, c \ldots m)$ (N > m) where in this case, $y_i = N_\beta$ and $x_i = N_c/N_\gamma$ or $y_i = N_\beta N_\gamma/N_c$ and $x_i = N_\gamma/N_c$. Since the function is linear in the coefficients (a, b, c ... m) their experimental evaluation is achieved by the usual least squares method of minimizing the sum of the weighted residuals. But this is equivalent to the minimization of $x^2$, i.e., $x^2 = \sum (w_i V_i^2/\sigma^2) = \sum (V_i/\sigma_i)^2$ where the residual $V_i = y_i - f(x_i)$, $w_i$ is the weight associated with the observed residual and $\sigma$ the variance of the residual of unit weight. The variance of this residual function is obtained in terms of the independent experimental parameters $P_j$ from $\sigma_i^2 = \sum_j \{\delta[y - f(x)]/\delta P_j\}_i^2 (\Delta P_j)_i^2$. As these variance calculations for individual measurements depend on the functions F or G and these depend on weights which are themselves variance functions, the final solution is based on an iterative procedure. This results in a successively closer approximation to the final best fit. (auth)

**1627** CORRECTIONS FOR $\beta$ ABSORPTION IN THE SOURCE MOUNT IN $4\pi\beta$ COUNTING. Sangiust, V.; Terrani, M. (Politecnico di Milano, Milan). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/67, 10p. (CONF-661012-23). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

In $4\pi\beta$ counting an important source of error is the absorption of radiation in the mounting film on which the source is deposited; for this reason very thin mounting films (20–30 $\mu g/cm^2$) are usually employed. A method is proposed here to correct for $\beta$ absorption in the source mount, which is shown to be valid also for thick

mounts (of the order of 1 mg/cm$^2$). The method consists in making a series of mounts of the same source sandwiched in foils of increasing thickness and then fitting the data obtained with the expression $I/I_0 = [e^{-\mu t} - \mu t \int^{\infty}(e^{-x}/\mu t^x)dx]$ which is derived supposing that $\beta$ rays are absorbed exponentially with an absorption coefficient $\mu$ and where $I_0$ represents the counting with zero thickness and I the counting with the thickness t. In this expression the coefficient $\mu$ is varied until a best fit is obtained. When this is done the data from the calculations give directly the corrections for various thicknesses. The method was tested using aluminum foils 1.34 mg/cm$^2$ thick with various nuclides of different $\beta$ end point energies; satisfactory fits have been obtained even for $\beta$ end point energies as low as 0.156 MeV of $^{14}C$ and up to aluminum thicknesses for which a reduction of a factor of 40 in the original counting rate was reached. The data obtained together with a plot of the $\mu$-values derived against $\beta$ end point energies of the various nuclides studied are presented. (auth)

**1628** NEW METHOD FOR THE MEASUREMENT OF THE GAMMA SENSITIVITY OF $4\pi\beta$ GAS COUNTERS. Urquhart, D. F. (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/27, 23p. (CONF-661012-26). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

The unwanted gamma sensitivity of $4\pi\beta$ gas counters used in $\beta$-$\gamma$-coincidence counting is due mainly to four factors. These are the effects of photon interactions with the source material, the foils supporting the source, the counting gas and the counter walls. The gas effect may be calculated fairly simply. Measurements of the forward and backward emission of electrons from thin metal foils produced by narrow gamma ray beams provide data from which the foil and wall effects may be calculated for spherical and cylindrical $4\pi$ gas counters. Because of the great irregularity in the thickness of evaporated sources, the source effect is not predictable, but the gamma beam experiments provide some idea of the possible magnitude of this factor. The information presented makes it possible to calculate the intrinsic gamma sensitivity in the range of gamma energies from 0.323 to 1.25 MeV, for thick-walled counters made of perspex, aluminum, steel, copper or gold, filled with methane, argon-methane or helium-isobutane. The accuracy of these measurements is estimated to be better than ±20%. The results presented can be used to design a $4\pi$ gas counter to obtain minimum gamma sensitivity and an example is given of the large reduction which can be expected from such a design. The gamma sensitivity indicated by these experiments is, in general, significantly lower than predicted by the method of Williams and Campion. From measurements made of the foil effect, it is concluded that in the latter method, the foils required to make significant changes in the beta efficiency may be thick enough to make a significant disturbance to the gamma sensitivity. Two Geiger flow counters which were specially designed for these experiments are described briefly. (auth)

**1629** COINCIDENCE COUNTING RATES WITH DELAY. Miguel, M.; Houtermans, H. (International Atomic Energy Agency, Vienna). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/60, 18p. (In French). (CONF-661012-19). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

In coincidence counting not only the true coincidences (corresponding to one disintegration), but also the random coincidences, depend on the delay between the two counting channels, as pointed out by Gandy (1961). For very large delays the counting rate clearly does not change any more with the delay, but for delays comparable with the dead-times, the counting rate can be much lower than given by the usual formula $2\tau AB$ (A,B = counting rates, $\tau$ = coincidence resolution time). In general, it is not possible to determine $\tau$ by simply delaying one channel just enough to eliminate all true coincidences. Experimental curves of the coincidence counting rates from a $4\pi\beta$-$\gamma$ coincidence apparatus as a function of the delay are given as well as an approximate formula which describes the results fairly well. For the routine determination of $\tau$, in the IAEA laboratory, one counting channel is replaced by a generator of regular pulses. (auth)

**1630** USE OF NUCLEAR EMULSIONS FOR NEUTRON SPECTROMETRY: RESULTS OF MEASUREMENTS MADE ON THE ACCELERATORS OF SACLAY NUCLEAR RESEARCH CENTER. Vialettes, H.; le Thanh, P. (CEN, Saclay, France). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/27, 48p. (In French). (CONF-660807-34). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The use of nuclear emulsions for neutron spectrometry is well known and many experimental data have already been published. Generally speaking, these findings relate to neutron spectra obtained by the direct interaction of beams. However, it is also important, for radiological protection work, to know the energy spectra of scattered neutrons in nuclear plants. A study of the spectra of scattered and degraded neutrons obtained in work with accelerators is presented. The method involving recoil protons produced by the elastic scattering of neutrons on the hydrogen nuclei present in the emulsion (Ilford K-2 emulsion, 400 $\mu$m thick) is used. The difficulty of applying the conventional processes known for beams in the standard case of neutrons arriving from all directions is discussed. The neutrons are degraded and their spectrum is a function of direction. It is no longer possible to collimate a beam and account has to be taken of all neutrons received by the emulsion within the $4\pi$ sr solid angle. Experimental procedures, development, and reading techniques and the practical difficulties encountered are also discussed. The spectrum obtained with a Pu–Be source is cited as a test of the method. Spectra obtained on Saclay's medium-energy accelerators for the case of operations involving protons, deuterons and alpha particles are presented. The results show, in particular, the various energy spectra obtained according to the place of measurement in a given accelerator. (auth)

**1631** MEASUREMENT OF FAST NEUTRON FLUENCE BY MEANS OF SILICON P-N JUNCTIONS. Blanc, D. (Faculte des Sciences, Toulouse); Casanovas, J.; Lagueny, P.; Peyre-Lavigne, A.; Chapuis, A. M.; Soudain, G. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/33, 12p. (In French). (CONF-660807-40). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The fluence determination is based on an entirely new principle, that of measuring variation under irradiation in the electric capacity of a surface-barrier p-n junction. This variation is caused by the appearance in the forbidden band of energy levels due to the defects introduced by irradiation. Whether they are donors or acceptors, these levels have an influence on minority carrier lifetime, the latter being inversely proportional to the fluence. On the whole, any variation in detector capacity can be related to the neutron fluence value. For such measurements it is advantageous to determine various characteristic parameters: the influence of the surrounding medium (oxygen, water vapor, etc.) is reduced by the creation, after chemical attack, of a layer of oxide by heating in an oxygen atmosphere; and variation in capacity has been studied as a function of frequency (from 50 c/s to $10^6$ c/s) and of the resistivity of the silicon (600-10,000 ohm-cm). These studies made it possible to determine the form of space charge and the accumulation, depletion and inversion capacities. On the whole, since the capacity of the detector was known, frequency and applied-voltage values were chosen which corresponded to maximum sensitivity for any variation in capacity. Examples of practical applications are given. (auth)

**1632** AUTOMATIC DATA PROCESSING FOR DIGITAL AUTOFLUOROSCOPE SCINTILLATION CAMERA. Spergel, Philip (Baird-Atomic, Inc., Cambridge, Mass.). 19p. (CONF-660642-3). ORAU. Gmelin, AED-CONF-66-237-1.

From Society of Nuclear Medicine, 13th Annual Meeting, Philadelphia.

A Digital Autofluoroscope was designed with an internal special-purpose data processor to provide the operator with automatic computation of the accumulated detector data. This computer gives the doctor the ability to optimize the data display without destroying the stored information. The computer will automatically do background subtraction, data averaging, and section integration. The accumulated data are permanently stored on a magnetic tape so that there can be further processing of the digital data on the AUTOFLUOROSCOPE console or on an off-line digital computer. The off-line computer can be programmed to generate new magnetic tapes that can be played back into the Digital AUTOFLUOROSCOPE console. These new tapes can be the result of sophisticated computer analysis. (auth)

**1633** SHORT $BF_3$ COUNTERS AND THEIR USE WITH SPHERICAL MODERATORS: PHYSICAL CHARACTERISTICS AND CHOICE OF USEFUL THICKNESSES OF THE MODERATOR. de Kerviler, H.; Tardy-Joubert, Ph. (CEN, Saclay, France). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/30, 16p. (In French). (CONF-660807-32). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The anisotropy of standard $BF_3$ counters placed in cylindrical moderators is considerable, and in scattered neutron fluxes may

lead to measurement errors of as much as a factor of 2. To eliminate this defect, a short $BF_3$ counter having both satisfactory sensitivity and a small useful volume was designed. The exact dimensions of this volume were determined by studying the collection regions (through analysis of the electric field present in the counter). These counters are placed in paraffin spheres whose useful thickness varies according to whether flux or dose-equivalent measurements are to be made. The limits of the method are described and the overall accuracy of measurement is discussed for a number of spectra commonly obtained at the installations, in order to make clear the terms in which the results are interpreted. The attractiveness of these counters, by comparison with lithium iodide scintillators, for measuring neutrons in the presence of gamma radiation is illustrated by an assessment of the maximum electron energy loss in the two instruments. (auth)

**1634** SEMICONDUCTOR AVALANCHE DETECTOR FOR HIGH GAMMA INTENSITIES. Bernt, H.; Keil, G.; Ruge, I. (Technische Hochschule, Munich). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/42, 18p. (CONF-661005-7). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

A silicon radiation detector is described that uses avalanche multiplication of carriers similar to a G.M. counter. The detector is a p-n diode operated in the reverse direction beyond its breakdown. (B.G.D.)

**1635** FAST TESTING OF THE PERFORMANCE OF RADIATION COUNTERS BY SINGLE-CHANNEL COUNTING. Houtermans, H.; Miguel, M.; Werner, E. (International Atomic Energy Agency, Vienna). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-79/61. 16p. (CONF-661012-11). DTIE.

From IAEA Symposium on the Standardization of Radionuclides, Vienna.

Single-channel counting is recommended for testing the performance of a radiation detector normally used for integral counting. One example is the $4\pi$ proportional counter. Conventionally, the integral counting rate is measured as a function of the high voltage; plateau length and plateau slope are the criteria. Ideally, all true pulses (produced within some 100 ns after the emission of the particle) must be counted, but not the spurious counts which arrive sometimes up to some 100 $\mu$s later than the true pulses, and which, fortunately, have much smaller amplitudes. In a good counter both kinds are separated by a deep valley in the pulse height spectrum. Setting the detection threshold for integral counting at the bottom of the valley is the best working point for the given experimental conditions. This can be done by scanning the pulse height spectrum with a channel between, say, 0.5 and 1.5 volts. The channel position, the electronic gain or the high voltage may be used as scanning parameter. This test procedure, with a ratio upper level to lower level of 3:1 and variation of the high voltage has routinely been used for several years in the IAEA laboratory. Typical test curves are given for $^{32}P$, $^{203}Hg$ and $^{35}S$ and different conditions. Since in this case the small difference between two big statistical counts is measured directly, a counting time of 20 seconds per point is normally enough. In a few minutes one can determine the working high voltage as well as the maximum error due to loosing true pulses or counting spurious ones. Another example is low-threshold integral $\gamma$-counting with an NaI crystal. In liquid scintillation counting, differential tests are also very useful. (auth)

**1636** SODIUM IODIDE SCINTILLATION COUNTER FOR ACCURATE MEASUREMENTS OF THE GAMMA-RAY BACKGROUND. Pensko, J. (Central Lab. for Radiological Protection, Warsaw). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/39, 20p. (CONF-661005-17). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

An absolute method is presented for the dose rate measurements of the natural and artificial (from nuclear explosions) gamma-ray background with a sodium iodide scintillation counter. The work was performed for preparation of the technique used for population dose measurements in Poland. The angular response of the counter and the natural beta and cosmic radiation cause a change of a few per cent in the calibration factor. The energy response of the counter was taken into account by simulating the natural gamma-ray background spectrum with radium and $^{131}I$ standard sources. This method makes it possible to determine the global gamma background dose rate with an overall error not exceeding ±7.5%. The stability of the lower discrimination level (300 keV) was kept better than ±5%. (auth)

**1637** HUMIDITY INSENSITIVE PROPORTIONAL COUNTER HAVING A HEATING SOURCE CONNECTED TO A WIRE ANODE. Borkowski, C. J.; Ferrari, A. M. R.; Fox, R. J. (to U. S. Atomic Energy Commission). U. S. Patent 3,288,999. Nov. 29, 1966.

A proportional counter is designed for the detection of alpha or beta particles, which is not affected by high relative humidity. This is accomplished by providing a small battery in series with the central anode wire of the counter for heating the anode wire only. (AEC)

**1638** RADIATION DETECTORS. Hyun, Kyung Ho (to English Electric Co., Ltd.). British Patent 1,046,235. Oct. 19, 1966. Filed Aug. 23, 1963.

An ionization chamber is designed for detecting neutron or gamma flux in a nuclear reactor. The ionization chamber includes an enclosed vessel in which a plurality of polarizing plate electrodes are arranged parallel to a plurality of collector plate electrodes. Examples of suitable materials for the vessel and electrodes include chemically pure vanadium and titanium respectively. (L.B.S.)

**1639** DETECTOR FOR IONIZING ELECTROMAGNETIC RADIATION. Hosemann, R.; Warrikhoff, Harald F. H. German Patent 1,221,367. July 21, 1966. Filed July 18, 1960.

A detector which operates on the principle of absorbing the electromagnetic radiation (photons) to be detected and of emitting charged particles (electrons) to be collected comprises an emitter electrode and a counterelectrode collecting the emitted charge carriers. In order to achieve a detector sensitivity which is uniform for all wavelengths the emitter electrode is composed of at least two layers of different atomic number (Al,Pb). The material and the thickness of the layers are chosen in such a way that the layer adjacent to the counterelectrode serves as electron emitter as well as energy dependent filter for the electrons emitted from the other, deeper layers. (Gmelin Inst.)

**1640** DEVICE FOR THE MEASUREMENT OF CURRENTS OF LESS THAN $10^{-12}$A FOR A DOSE RATE METER. Elsaesser, Martin (to Siemens and Halske AG). German Patent 1,220,528. July 7, 1966. Filed July 6, 1961.

The dose rate meter consists of two air-filled ionization chambers one of which is the reference chamber irradiated by a radioactive reference source. The reference chamber is provided with means for varying either the distance of the reference source from the chamber or the position of a radiation absorbing shield in response to the output signal of an amplifier the bias voltage of which is obtained by subtraction between the output signals of the two ionization chambers. The reference chamber is constructed in the shape of a pointer instrument the pointer setting being proportional to the position of the shield or the distance of the reference source. (Gmelin Inst.)

## Radiation Dosimeters

*Refer also to abstract 1375.*

**1641** (USNRDL-TR-1037) CHARGED PARTICLE TRACKS IN POLYMERS. NUMBER 2. REGISTRATION OF HEAVY IONS DURING THE FLIGHT OF GEMINI VI. Benton, E. V.; Colliver, M. M. (Naval Radiological Defense Lab., San Francisco, Calif.). June 23, 1966. 26p.

Several small disks of cellulose nitrate plastic were included as a part of a dosimetry package aboard the Gemini VI spacecraft for the purpose of recording the heavy component of the primary cosmic radiation. An average of 10 tracks/cm$^2$-day was found in the plastic detectors. Most of these were judged to be tracks of heavy recoil ions; about 1 track/cm$^2$-day was judged to be due to the primary cosmic ray particles. (auth)

**1642** $\gamma$-RAY DOSIMETRY BY MEANS OF A THERMOLUMINESCENT DOSIMETER UTILIZING NATURAL $CaF_2$:Mn. Szentirmay, Zs.; Patko, J.; Orban, G.; Goergey, M. (Lajos Kossuth Univ., Debrecen, Hungary). Acta Phys. Chim. Debrecina, 11: 41-5(1965).

The thermoluminescence properties of natural $CaF_2$ Mn of Slovak origin were investigated. They found a linear response between the absorbed dose and the emitted thermoluminescent light over the range $1-10^3$ rads. For the evaluation of the irradiated dosimeters a simple sensitive apparatus was constructed. The thermoluminescent dosimeters using natural $CaF_2$ Mn are inexpensive, small size and have practically unlimited life time. The dosimeters are suitable for clinical dosimetry even in body cavities. (auth)

**1643** COMPARISON OF CALIBRATION METHODS FOR $\beta$ DOSIMETERS. Hermann. D. (Institut fuer Angewandte Radio-

aktivitaet, Leipzig). Nukleonik, 8: 320-9(Aug. 1966). (In German).

Two calibration techniques for $\beta$-dosimeters are compared, namely the calibration in "free air" and the calibration in contact with a volume source. The $\beta$ radiation dose in "free air" was measured for point-sources of various $\beta$-emitters by means of ionization-chambers with extrapolation to zero wall-thickness of the chamber. The dose at the surface of volume sources and in various depths of absorbing materials was measured by means of another ionization chamber with extrapolation to zero air volume. The $\beta$-dose was calculated in both cases using a theory of Spencer and formulas of Loevinger. The measured values of dose were used to calibrate photographic film-dosimeters. It was shown that the two calibration techniques are not equivalent. In general, one must choose a calibration-technique for $\beta$-dosimeters such that the gradient of the dose rate in the detector, caused by physical processes and by geometrical circumstances, is exactly the same for the calibration and the measurements to be made. (auth)

**1644** PORTABLE UV DOSIMETER. Simidchiev, D.; Kehlibarov, T. (Inst. of Hydrology and Meteorology, Academy of Sciences, Bulgaria. Inst. of Physics, Sofia). Compt. Rend. Acad. Bulg. Sci., 19: 277-9(1966).

A direct reading instrument for measuring uv is described. Readings of uv intensity are made on the dial of a microammeter, which is used to control the voltage of the batteries. The sensor of the uv dosimeter is a sodium photocell working with an anode voltage of 200 in the saturated part of the volt-ampere curves of the photocell. The current of the photocell drives a transistorized differential amplifier incorporating two germanium triodes in the collector circuitry of which a uv intensity meter is tapped. The gain required is comparatively small, hence permitting the use of a one-stage amplifier. Overall error of the dosimeter when calibrated by means of a standard uv lamp did not exceed 5%. (H.G.D.)

**1645** DOSIMETRIC EVALUATION OF ELECTRICAL PULSE DISCHARGE EFFECT UPON AQUEOUS MEDIA. Gubergrits, M.; Brodskaya, B.; Paalme, L. Izv. Akad. Nauk Est. SSR, Ser. Fiz. Mat. Tekh. Nauk, 15: 462-72(1966). (In Russian).

The total physico-chemical effect of high pressure pulse-discharge action on liquid (aqueous) media is evaluated by means of some dosimetric chemical systems widely used in radiation chemistry. The experimental investigation deals with three of such systems: the Fricke dosimeter (a sulfuric acid solution containing ferrous ions); an aerated neutral aqueous solution of methylene blue and neutral aerated water. The experimental results are quantitatively comparable with the effect of pulse irradiation of high intensity (of the order $10^{23}$ eV/ml · s) upon such systems. The highest limit of the "chemical efficiency" value of the investigated process may be considered to be 30–40%. (auth)

**1646** USE OF SYNTHETIC POLYMERS IN NUCLEAR EMULSIONS FOR FAST-NEUTRON DOSIMETRY. Bradna, F. (Ustav Jadernych Vyskumu Ceskoslovenska Akademie Ved, Prague). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/43, 16p. (In Russian). (CONF-660807-13). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The results of tests on the properties of hydrogen-enriched nuclear emulsions for detecting fast neutrons are described. It also compares the dosimetric characteristics of these new emulsions with those of the gelatin emulsions used up to the present. The most promising of the series of polymers synthesized in the laboratory were: polyvinylacetal of 2,4-disulfonic acid benzaldehyde and the co-polymer of $\alpha$-acetylaminoacrylic acid and N-vinylpyrrolidone. The possibility of using polyvinyl alcohol solutions with a higher hydrogen content than the above polymers for saturating polymergelatin emulsions and for preparing from them films for use as proton radiators was also studied. (B.G.D.)

**1647** PERSONNEL PHOTODOSIMETER COMBINED WITH RESONANCE DETECTORS FOR MEASURING THERMAL AND INTERMEDIATE NEUTRON DOSES. Zeinalov, E. I.; Obaturov, G. M.; Shalin, V. A.; Chumbarov, Yu. K. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/58, 22p. (In Russian). (CONF-660807-37). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

Theoretical and experimental studies relating to the use of a photodosimeter in combination with various resonance detectors (indium, rhodium, silver) and with cadmium are described, for measuring thermal and intermediate neutron doses. Drawing on theoretical calculations and experiments a personnel dosimeter (IFKNG) based on a serially produced personnel photodosimeter for gamma radiation was designed, the instruments can measure thermal and intermediate neutron doses and gamma-ray doses. The dosimeter has five filters: Pb, Sn, Sn + In, Cd + In and Cd + Sn. The intermediate neutron dose is determined from the difference in density between the fourth and fifth filters. The difference in density between the second and third filters can be used to measure the total dose of thermal and intermediate neutrons. The characteristics of this dosimeter have been studied under realistic conditions on two types of reactor (the BR-5 and the reactor of the first atomic power station), allowance having been made for the contributions of scattered and reflected neutrons from a phantom representing the human trunk. The results of the studies showed that the sensitivity of the dosimeter to thermal and intermediate neutrons coincides, within limits of error, for both reactors and undergoes no change in the vicinity of the reactor. The proposed dosimeter using x ray film type RM-5-4 makes it possible to measure easily and with sufficient accuracy thermal neutron doses beginning with 0.005 rem, intermediate neutron doses in the energy range 0.4 eV-1 MeV beginning with 0.003 rem and gamma radiation beginning with 0.015 R. (auth)

**1648** IN-VIVO GAMMA-RAY SPECTROMETER FOR ISOTOPE METABOLISM STUDIES IN CATTLE. Johnson, James E.; Ward, Gerald M. (Colorado State Univ., Fort Collins). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-75/24, 8p. (CONF-660711-1). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

A crystal-type whole-body counter has been modified for in vivo gamma-ray spectrometry of large animals. The counter shield is a 75-ton steel room of 8 ft by 8 ft by 8 ft inside dimensions. The gamma-ray detector is a single 4 in. thick 8 in. diameter NaI (Tl) crystal. The counter was initially designed to measure fallout $^{137}$Cs body burdens in cattle as a function of dietary intake, which in turn was related to the fallout rate. The relations of $^{137}$Cs body burdens to milk concentrations at equilibrium have been studied. Animals are washed and contained in a mobile restraining chute for whole-body counting. Urine and fecal collectors are fitted to the animal during the counting period. Body burdens as low as 100 nanocuries of $^{137}$Cs as well as total body potassium (from the $^{40}$K gamma ray) could be measured easily in a 30-minute counting period. The coefficient of variation of the estimate of total body potassium was 5 per cent for a single cow counted repeatedly. Counting times are proportionately shorter in isotope tracer experiments. In experiments to determine the biological half-time of $^{134}$Cs in cattle after oral doses of less than 2.0 microcuries, body burdens could be measured in 10-minute counting periods several months after the isotope was no longer detectable in milk or urine. From oral doses of $^{134}$Cs to lactating cows, the milk secretion rate function was found to contain three exponential terms. The last term was interpreted as loss from the muscle compartment, and this was verified by the biological half-time as measured in the animal using the whole-body counter. (auth)

**1649** USE OF LiF THERMOLUMINESCENCE FOR INTERCOMPARISON BY MAILED DOSIMETERS. Almond, Peter R.; Shalek, Robert J. (Univ. of Texas, Houston). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/26, 8p. (CONF-661005-4). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

The use of lithium fluoride as a mailed dosimeter for intercomparison of dose has previously been described and the result of an extensive intercomparison between M. D. Anderson and Memorial Hospital, New York, has been reported. Since intercomparisons between this institution and six other institutions in the United States, Canada, and England have been or are being carried out, the techniques developed from this experience will be described. The use of an intercomparison becomes important for high-energy x-ray and electron beams, because national laboratories do not, at present, provide calibrations for portable ion chambers for these radiations. By intercomparisons, participating institutions can determine if their absorbed dose unit, the rad, is equivalent. Since the sensitivity of the dosimeter varies with energy, the intercomparisons are made at known energies and the energy dependence of the dosimeter must be known. Capsules of LiF are exposed to several dose levels at each institution in order to provide curves of LiF response versus dose for comparison. To overcome the decay of the thermoluminescence after irradiation, arrangements are made to expose the dosimeters at about the same time; the thermoluminescence of all capsules is measured consecutively on the same instrument at the initiating institution. To investigate the effect of travel and climate upon the dosimeters, irradiated and unirradiated controls are sent and a similar set is kept at the initiating institution. It is desirable for both institutions to act as initiating institutions on different intercomparisons. Repetition of intercomparisons is desirable since a single intercomparison may vary from the average by 5%. Usually, however, replicates agree to within 2%. (auth)

**1650** THERMOLUMINESCENT DOSIMETERS OF LiF AND $CaF_2$:Mn INCORPORATED IN TEFLON. Bjarngard, B. E.; Jones, D. (Controls for Radiation, Inc., Cambridge, Mass.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/24, 8p. (CONF-661005-8). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

Thermoluminescence dosimeters fabricated by incorporating thermoluminescent phosphors in polytetrafluoroethylene (Teflon) are described. The production technique is based on a careful mixing of phosphor powder of small grain size with Teflon, followed by a moulding or extrusion process and the final mechanical fabrication of dosimeters of various shapes. The dosimeters are then subjected to a heat treatment to eliminate background and to control sensitivity. The technique has been successfully used for the production of reusable dosimeters in large quantities with little variation in sensitivity. The various parameters in the production which influence the performance of the dosimeters are analyzed, as well as the special problems in the readout technique that affect accuracy and background. The overall precision in the measurements is characterized by a standard deviation of ±3% without individual calibration of the dosimeters. Most of the measurements described were performed with LiF–Teflon discs 13 mm in diameter of various thickness and LiF–Teflon rods 1 mm in diameter. Discs 0.4 mm thick allow measurements down to 50 millirad (±15% standard deviation) and 6-mm-long rods down to 1 rad (±20% standard deviation). Discs of $CaF_2$:Mn in Teflon were used mainly for high doses, up to 1 megarad, since LiF can be used only up to about 0.1 megarad. The response of the dosimeters to radiation is reviewed, e.g., energy dependence, dose and dose rate dependence, and fading. The use of these dosimeters for absorbed dose measurements is discussed, and experimental results are compared to a simplified Bragg-Gray theory. Particular reference is made to dose measurements in tissue and at interfaces. (auth)

**1651** SOME CHARACTERISTICS OF RPL DOSIMETER GLASSES. Becker, Klaus (Kernforschungszentrum, Juelich, Ger.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/31, 24p. (CONF-661005-5). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

Some of the basic dosimetric properties of experimental and commercially available American, Japanese, French, and German silver-activated phosphate glasses having either a different glass base but similar silver content, or a constant glass base but different silver contents, were compared under identical conditions. In particular: the kinetic behavior (build-up and fading of the radiophotoluminescence RPL) after high-intensity gamma exposure was studied under different conditions, such as storage at room and increased temperatures before and after stabilization by a short heat treatment, and the relative and absolute RPL spectra of the glasses were measured under different conditions (dose level, build-up, temperature treatment). On the basis of these results, a proper definition of the terms predose and sensitivity of the RPL dosimeters and their relative significance is possible. The practical consequences, in particular the possibilities of avoiding errors in RPL measurements immediately or a very long time after exposure or by using different readers, are discussed briefly. (auth)

**1652** USE OF LITHIUM FLUORIDE THERMOLUMINESCENT DOSIMETERS WITH HIGH ENERGY ELECTRON BEAMS. Almond, Peter R.; Wright, Ann; Lontz II, J. F. (Univ. of Texas, Houston). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/22, 16p. (CONF-661005-3). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

In order to use lithium fluoride thermoluminescent dosimeters for dose distribution and calibration measurements with high energy electrons, the energy and dose response of the dosimeter must be known. The energy dependence of the dosimeter was measured from an effective energy of 24 keV to electron energies of 6-24 MeV. It was found that the response of LiF with energy follows closely Burch's LET with energy which may give some indication to the mechanism of the thermoluminescent process. It was also found that the sensitivity of the dosimeter is less by approximately 10% for high energy electrons than it is for $^{60}$Co $\gamma$ rays. The basic dose calibrations for the electrons were made with the ferrous sulfate dosimeter using a G-value of 15.4 eq/100 eV. This yield was measured at energies between 13.25 and 24 MeV using an aluminum calorimeter and the average value was found to be 15.38 ± 0.35 eq/100 eV. Measurements of the G-value are being extended to 35 MeV. The dose dependence of the dosimeter was measured between 50 and 1400 rads for 15-MeV electrons and $^{60}$Co $\gamma$ rays, and both curves were found to become superlinear at approximately 500 rads, which is lower than normally reported. To investigate the usefulness of the dosimeter for dose distribution measurements standard depth dose curves in water were measured for various electron energies and compared to ion chamber measurements. The two sets of curves were found to agree within experimental error. Small corrections can be made for the energy dependence of the LiF and the ion chamber. These corrections only amount to a few per cent and can generally be neglected within the accuracy of the experiments. The LiF teflon disc dosimeters were also investigated and good agreement with ion chamber measurements was again obtained in water and cork phantoms. These discs make it possible to study the dose distribution of electrons in inhomogeneous materials and are being used to investigate this problem. (auth)

**1653** SILICON PN JUNCTION SURFACE BARRIER DETECTORS AND THEIR APPLICATION TO THE DOSIMETRY OF X- AND $\gamma$-RAY BEAMS. Parker, R. P.; Morley, B. J. (Inst. of Cancer Research, Sutton, Eng.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/40. 20p. (CONF-661005-16). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

The recent availability of very pure semiconductors such as silicon permits the construction of solid-state ionization chambers. The basic mechanism of such a device will be briefly described, particularly in relation to its gas-filled counterpart. On exposure to ionizing radiation the sizes of the charged pulses formed in the device are proportional to the energy lost in the silicon, and so the pulses may either be treated individually or d-c operation is possible. The theory of both these modes will be discussed and the results compared with experiment. Under pulse operation a sensitive volume of only 0.04 ml permits dose-rate determination down to $10^{-5}$ rad/min and a study was made of the response to various $\gamma$-emitting radioisotopes. The possibility of using the device under approximate wavelength independent conditions will be discussed and the effect of ambient temperature considered. When d-c measurements are carried out under applied bias, difficulty is experienced due to the leakage current, and it will be shown that the device is best used without bias provided long minority carrier lifetime material is used. Here the photovoltaic effect is utilized and the current which flows, when measured under short-circuit conditions, is a linear function of dose rate. Alternatively the voltage generated across the junction may be determined by a high input impedance circuit in which case there is a logarithmic response over a restricted dose-rate range. The current measurements are temperature independent between 0° and 50°C but this is not true for the voltage measurements. Consideration will be given to the wavelength dependence of the device from both a theoretical and experimental standpoint and data will be presented pertaining to the effect of radiation damage in relation to the various modes of use. Comments are presented on our practical experience with these devices and a comparison will be made with other dosimetric systems suitable for in vitro studies. The silicon devices are very useful as dose-rate meters in situations where their high sensitivity, small size and ruggedness are advantageous. (auth)

**1654** CHANGES IN THE OPTICAL ABSORPTION SPECTRUM OF IRRADIATED RED PERSPEX 400. Walsh, Karen. 12p. (CONF-660639-4). ORAU. Gmelin, AED-CONF-66-221-6.

From Congress-Canadian Association of Physicists, Sherbrooke, Quebec.

Results of experiments to determine the feasibility of using the plastic material dyed polymethylmethacrylate, Perspex Red 400, as a radiation dosimeter are reported. Since the sensitivity of the plastic depends on its water content, a pretreatment process is necessary if the plastic is to yield acceptable results as a dosimeter. After predrying the dosimeter in a silica gel desiccator and making all absorbancy measurements at 615 mμ, the dosimeters were suitable for relatively low doses of <1 MRAD and at relatively low dose rates of <0.015 MRAD and at relatively low dose rates of <0.015 MRAD/hr for a period of 40 days to ±2%. At high dose rates this is not true, but with proper choice of wavelength for the measurements to minimize fading, the dosimeters can be used at higher doses. (B.L.M.)

**1655** SOLID STATE DOSIMETRY OF IONIZING RADIATION. Schulman, J. H. (Naval Research Lab., Washington, D. C.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/1, 44p. (CONF-661005-19). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

A survey will be given of the principles which underlie radiation-induced changes in the optical properties of solids. Coloration

changes, photoluminescence changes, thermoluminescence, and infra-red stimulated luminescence will be given particular attention, and the close connections between these phenomena will be pointed out. The control of radiation sensitivity by adjustment of the chemical composition of the solid will be emphasized, including the extremely important role of impurities and structural imperfections. The application of these principles to solid state dosimetry will be illustrated by detailed descriptions of the two most widely employed types of solid state dosimeter systems: the radiophotoluminescence system, which employs various silver-activated phosphate glasses; and the thermoluminescence system, which employs various phosphors such as calcium fluoride or lithium fluoride. Comparisons will be made between the operational characteristics and performance of these two leading types of solid state dosimeter. (auth)

**1656** UV LASER EXCITATION FOR ULTRA SENSITIVE PHOTOLUMINESCENT DOSIMETRY. Kastner, Jacob; Eggenberger, D. N.; Longnecker, A.; King, David; Schutt, Dale (Argonne National Lab., Ill.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/33, 6p. (CONF-661005-15). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

The factor which has limited the sensitivity of photoluminescent dosimetry has been the predose or matrix fluorescence background which is stimulated during readout by the usual continuous ultraviolet exposure. The signal-to-noise ratio has only been partially optimized by selective choice of filters and optical geometry. A microdosimetric system was conceived and investigated which is potentially capable of sensing extremely low radiation dosages (in the order of microrads). This system depends on the little-known fact that the decay time for the visible luminescence, which is a measure of the absorbed dose, is at least ten times longer than the decay of the indistinguishable visible fluorescence (to $\mu$v) which is an inherent characteristic of unexposed silver phosphate glasses. The system consists of an ultraviolet, 3500 Å, laser beam, with a Pockels cell such that it has complete cut-off in intensity in the order of nanoseconds, and gating circuitry to open the visible light-sensing photomultiplier at sufficient time delay to prevent it from sensing the ultraviolet or the predose fluorescence which decays in the order of 100 nanoseconds. In this way the signal-to-noise ratio can be vastly improved over what is possible by optical means. With such a system we were able, easily, to measure quantitatively one milliroentgen of cobalt-60 exposure. Further improvement of this system should enable us to do track visualization and/or in vivo biological microdosimetry with a spatial resolution in the order of ten microns. (auth)

**1657** MINIATURE LiF DOSIMETER FOR IN VIVO MEASUREMENTS. Benner, S.; Johansson, M.; Lindskoug, B.; Nyman, P. T. (Univ., Goteborg). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-78/25, 16p. (CONF-661005-6). DTIE.

From Symposium on Solid-State and Chemical Radiation Dosimetry, Vienna.

In radiobiological work there is a need for very narrow measuring probes which can be inserted in small cavities. To fill and empty very small containers would be difficult and time-consuming. A method with permanently filled containers which can be reused several times was developed. Each probe contains a number of small dosimeters within a narrow Teflon tube, so measurements are obtained at several points simultaneously. The read-out device is rather cheap because it is composed of apparatus easily available at any radiophysical laboratory. Measurements concerning the response per rad for high-energy electrons and $^{60}$Co are reported. This system was developed for internal measurements in smaller animals such as rabbits, especially in our experimental study of the radiation effect on rabbit lungs. Our aim is to calculate dose at different depths and to correlate the data with histopathological changes. Lung experiments are started by inserting a tube in the trachea of the anaesthetized animal. Through that tube the catheter with the LiF-probe is introduced into the bronchus of the left lobe under fluoroscopic control. The animal is then stretched out on a special table, the field is marked on the skin and the level of the probe is adjusted. In experimental radiation of the rabbit heart, a probe was inserted in the right chamber of the heart. Measurements in patients are in progress. (auth)

**1658** CALIBRATION OF GAMMA EMITTERS AND DOSIMETERS. Referovskii, Z. 10p. (In Russian). (CONF-641024-5). ORAU.

From Symposium on Use of Radioisotopes, Warsaw.

Methods for calibrating closed gamma sources and dosimeters are reviewed. The dose at various distances from the source, usually 20 to 120 cm, is measured using a graphite ionization chamber, and from the results the system constants are calculated. The dose from a moving gamma source may be determined with a series of dosimeters. The characteristics of a radiation beam must be determined; the location of the counting chamber being very important for a strongly collimated beam. The activity of the source must also be determined and a closed source constructed to determine the self-absorption and absorption by the capsule. This is done most simply by comparison with a standard. The energy characteristics of a dosimeter are determined usually with the use of $^{137}$Cs or $^{60}$Co. For gaging x-ray doses the absolute air chamber is used. Dosimeters may be calibrated by the comparison method or, more precisely, by the substitution method. The ionization current and charge may be measured by the deviation method or, more precisely, by the compensation method. (TTT)

## Radiometric Instruments

*Refer also to abstract 1530.*

**1659** (COO-1239-1) ABSORPTIOMETRY WITH BETA EXCITED X-RAY SOURCES. An Interim Report, March 1, 1964-August 31, 1965. Preuss, Luther E.; Bugenis, C.; Toothacker, W. (Edsel B. Ford Institute for Medical Research, Detroit, Mich. Physics Dept.). Mar. 1966. Contract AT(11-1)-1239. 35p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The applicability of beta-excited x-ray sources in substitution for the conventional x-ray machine was studied. Beta-excited x-ray sources of $^{147}$Pm with Cu, Fe, and Mo targets were tested as possible sources of x-ray photons for absorptiometry. Preliminary studies employing gross counting techniques showed that the beta-excited x-ray sources exhibit some promise in absorptiometry with certain solvent-solute combinations. These sources produce characteristic x rays as well as the bremsstrahlung continuum, and the application necessarily involves polychromatic absorptiometry. Certain factors of economy, small size, and stability are advantages of the beta-excited x-ray source. The low x-ray intensity is not a serious problem in this application and reproducible, standard absorption curves may be obtained from relatively small $^{147}$Pm sources. Standard deviations of 1 to 2 percent are possible in most determinations. A simple scaler-detector combination was used in this study which indicates that beta-excited source types other than the three above may profitably be used in absorptiometry. Work will be extended to new sources, improved detectors, and a multichannel analyzer in the study of selected regions of the absorbed beta-excited continuum. (auth)

**1660** SOME THEORETICAL PROBLEMS OF RADIOISOTOPE SCANNING. Ember, Gy.; Halasz, I. (Gamma Optical Works, Budapest). Acta Tech. Acad. Sci. Hung., 54: 385-94(July 12, 1966).

The minimums of observable activity differences in scanning techniques were investigated with the aid of statistical methods. The effect of sealing on the scan recording, the effect of logarithmic detection of the human eye on true observation, and conditions of the ideal projection were discussed. True observation was found to increase by increasing the quantity of isotope used until a maximum is reached; it decreases thereafter. The logarithmic nature of the subjective visualization was pointed out. Optimum picture can be attained by employing optimum amount of isotope and by applying simultaneously the photo-scanning to eliminate the logarithmic sensitivity of the human eye. (JPRS)

**1661** ON THE MEASUREMENT WITH GAMMA-RAYS OF THE DENSITIES OF COAL PILES AT THE MATSURAMA POWER STATION. Ono, Hironori; Machida, Tadao (Central Research Inst., Electric Power Industry, Tokyo). Gijutsu Kenkyusho Shoho, No. 65018, 1-29(June 1965). (In Japanese).

Density measurements were made on coal to determine density distribution in a compressed coal pile. Gamma surface measurements were compared to those made by conventional boring methods. Values made by boring showed an error of 6.2% caused by the space between the guide tube and the surrounding coal. Boring values were larger than surface $\alpha$-ray measurements. To obtain the average density with the $\gamma$-ray method, with a reliability of 95% within 1% error, it is necessary to use about 200 measuring points. (F.S.)

**1662** LEAK DETECTION BY RADIOKRYPTON: SENSITIVITY PLUS SAFETY. Brownell, L. E.; Farvar, M. A.; Levensky, K. F. (Univ. of Michigan, Ann Arbor). Space/Aeron., 46: No. 3, 86-7; 89-90; 93-4; 96(Aug. 1966).

Radiokrypton, $^{85}$Kr, is used efficiently, safely, and economically in the space program for leak detection both during static factory

testing and pre-launch check-out flight. Advantages in using $^{85}Kr$ are: it has a 10 yr half-life, is readily available in large quantities, is easy to detect in low concentrations, is soluble in lox and hydrocarbon fuels, and the detection equipment used with it is easy to handle. In leak testing, the system to be tested is pressurized with a mixture of $^{85}Kr$ and compressed air or N. A thin-walled 30 mg/cm$^2$ G-M tube held near the leak multiplies the leak signal to provide an easily detectable audio signal. Solid state detectors may be used with a preamplifier. The survey must be made more slowly with the solid state detector because of its lower count rate, but is more sensitive than the G-M tube. Krypton-85 may also be used for leakage measurements in enclosed volumes such as spacecraft cabins and fuel tanks. (F.S.)

**1663** DETERMINATION OF DENSITIES OF RESERVOIR SEDIMENTS IN SITU WITH A GAMMA PROBE. McHenry, J. Roger (Dept. of Agriculture, Oxford, Miss.). U. S. Dept. Agr. ARS 41-53: 10p(Apr. 1962).

The attenuation of $\gamma$ radiation on passing through matter was adapted for determining the densities in situ of reservoir sediments. The equipment is described, as well as the procedures for the necessary calibration of the detector instrument. The attenuation of $\gamma$ rays was found to be a linear (log) function of the density of the sediment. Excellent precision was obtained with the equipment described. In operation the $\gamma$ probe depends on the scattering of the emitted $\gamma$ rays and the attenuation measured is not of the emitted photons but of scattered and secondary emissions. Therefore, the relation measured is empirical because the exponential law of absorption is not followed. Calibration of the system is necessary to relate the empirical results to the desired end, that is, attenuation to changes in density. Because the Geiger-Mueller detection tubes used were separated from the radioactive source ($^{226}Ra$) by 6 in. of lead, so that all measured photons passed through the material under test, density determinations of layers less than 16 to 18 in. were not feasible except under special conditions. Despite this disadvantage the $\gamma$ probe provided a unique and reliable method for measuring reservoir sediment densities in situ. Sediments need not be consolidated; the $\gamma$ probe works equally as well in unconsolidated sediments. The profile densities obtained on the Power Line Dam reservoir, Lafayette County, Mississippi, are shown as typical of the field data obtained during 2 yr of investigation. (BBB)

**1664** USE OF THRESHOLD SPECTROMETRY UNDER ABOVE-GROUND CONDITIONS. Shatov, V. Ya. Vop. Rudn. Geofiz., Min. Geol. Okhrany Nedr SSSR, No. 5, 134-9(1965). (In Russian).

The energy discrimination thresholds for the SRP-2 radiometers were determined explicitly, and the results are given for gamma and beta rays. A determination of the nature of the anomalies was made from their intensity measurements on the energy thresholds. (J.F.P.)

**1665** HIGH-PRECISION GAMMA DENSITOMETER. Lakoshi, L.; Tabor, P.; Tot, M. 7p. (In Russian). (CONF-641024-2). ORAU.

From Symposium on Use of Radioisotopes, Warsaw.

Density gages based on absorption of radiation from radioisotopes, which have a precision of $10^{-2}$ g/cc, have been used since 1950. A new gage that has a precision of $10^{-3}$ to $10^{-4}$ g/cc is a complex system supplied with accessory compensating equipment. The detector is a 1 liter ionization chamber filled with argon at 125 atm pressure. The chamber sensitivity in the energy range 0.2 to 1.5 MeV is about $1.3 \times 10^{-8}$ amp/R/hr. The thermostatic data unit contains the detector, preamplifier, and high-voltage unit. The electronic amplifier is the most modern type of dynamic electrometer and ensures a long-lived electronic system, high precision in measurement, and dependability in constant use. A compensating voltage unit balances the voltage at the operating resistance of the ionization chamber and makes it possible to set the limits of measurement where desired. Formulas are developed for the relation between current generated and gamma quanta (for $^{60}Co$ and $^{137}Cs$ sources) and for handling errors. (TTT)

**1666** MINERAL MINING MACHINES. Cooper, Laurence Reade; Lawrence, Geoffrey Albert (to Coal Industry (Patents) Ltd.). British Patent 1,045,874. Oct. 19, 1966. Filed Apr. 19, 1962.

A mineral mining machine consisting of a $\gamma$-ray or x-ray source and a scintillation counter is responsive to radiation backscatter from material adjacent to the machine. Radiation from the source is directed into the adjacent mineral and part of the backscattered radiation impinges on the counter. The source and counter are mounted adjacent to each other in a radiation shield. The machine is used in steering, cutting or drilling machines in coal seams. Thulium-170 and $^{241}Am$ are suggested as radiation sources. (F.S.)

**1667** MEASURING HARDNESS BY USING BETA RADIATION. Varner, Donald Edmund (to Industrial Nucleonics Corp.). British Patent 1,038,998. Aug. 17, 1966. Filed Sept. 6, 1963.

A nondestructive hardness gage is described in which a beam of $\beta$ particles is directed to a metallic demagnetized workpiece having substantially homogeneous composition. The backscattered radiation is detected by a radiation detector which is calibrated to provide an electric signal proportional to the intensity of the reflected or backscattered radiation. Krypton-85 is suggested for the $\beta$ source and an ion chamber for the detector. (F.S.)

## Miscellaneous Instruments and Components

*Refer also to abstract 1482.*

**1668** (AD-629562) 587-KVA 24,000-RPM ALTERNATOR. PART NO. 546136-1-1. Final Report. McCarty, F. B.; Tarhov, S. (Garrett Corp., Los Angeles, Calif. AiResearch Mfg. Div.). Dec. 28, 1965. Contract DA-44-009-eng-5251. 47p. (F-4341(Rev. 1)). CFSTI $4.60 cy, $0.50 mn.

The description of the alternator, installation and operation instructions, and development test data needed to ascertain the capability of the machine are discussed. The testing conducted was undertaken to verify the attainment of the design objectives for this machine. Operation of the alternator at full load conditions was not conducted because available laboratory equipment was not adequate for such a high power level. (auth)

**1669** (AD-633280) LOW INDUCTANCE GASEOUS SWITCH TUBE. Josephson, V. (Aerospace Corp., El Segundo, Calif.). Dec. 1965. Contract AF 04(695)-669. 11p. (TDR-669(6550-10)-1). CFSTI $1.00 cy, $0.50 mn.

A low inductance gaseous switch tube was designed and tested, which permits high current (>150,000 amp) switching of power at potentials up to 20 kV without deterioration of electrodes due to current pinching. The switch is so designed that triggering is accomplished externally with very low (<0.1 micro sec) time jitter over a wide range (5 to 20 kV) of operating voltages. (auth)

**1670** (AD-635040) DESIGN, CONSTRUCTION, AND TESTING OF A MOESSBAUER SPECTROMETER. O'Toole, Patrick James (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering). June 1966. 104p. (GSP/PH-66-14). CFSTI $4.00 cy, $0.75 mn.

Thesis.

The purpose of this project was the construction and testing of an electromechanical Mössbauer spectrometer with constant acceleration mode of operation. Design of the spectrometer is based on the original plan of the National Bureau of Standards. The spectrometer is designed for use in both research and education. Velocity calibration of the spectrometer was obtained by use of a voltage-to-frequency converter, a multichannel analyzer and an F3(57) absorption spectrum. In the range checked, the linearity of the system is 0.10%. Sample results obtained from Fe(57) source-absorber combinations are presented. The results indicate agreement to within plus or minus 5% of values in the literature. (auth)

**1671** (EUR-3063.3) ELECTRONIC INSTRUMENTS FOR RADIATION DETECTORS AND CONTROL SYSTEMS. Benoit, R.; De Blust, E.; Isabella, L.; Mandl, V.; Melandrone, G. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 34p. Dep. mn.

Electronics instruments developed in the Nuclear Chemistry Laboratory of the Chemistry Department are described. They include low-noise amplifiers for solid state detectors and gridded ionization chambers, fast electronics, power systems for the construction of lithium drifted semiconductor detectors and automatic controls for activation analysis and radiochemical separations. (auth)

**1672** (INR-742/II/PS) FOCUSING OF THE TIME-OF-FLIGHT DIFFRACTOMETER FOR STRUCTURE ANALYSIS. Holas, A. (Institute of Nuclear Research, Warsaw (Poland)). Aug. 1966. 22p. Dep.

The setting up of a neutron time-of-flight diffractometer for crystal structure analysis, which allows the use of large source windows, large samples and large detectors without broadening of the diffraction peak is described. (auth)

**1673** (IS-1203) MAGNETIC FLOWMETER CALIBRATION. Bluhm, Delwyn D.; Smith, Dale L.; Fisher, R. W. (Ames Lab., Iowa). Aug. 1966. Contract W-7405-eng-82. 45p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A direct current magnetic flowmeter was accurately calibrated both theoretically and experimentally for measuring the flow rate of 100 to 500°C liquid sodium in $\frac{3}{4}$ in. schedule 40 Inconel 600 pipe. A theoretical calibration factor, $Y_{TH}$, was computed for sodium loop temperatures from 100 to 600°C. An experimental calculation factor, $Y_{EXP}$, was determined for sodium loop temperatures from 143 to 527°C. Before determining the factor $Y_{EXP}$, it was necessary to measure accurately the flowmeter magnetic field with a light-beam-type fluxmeter for magnet temperatures from 20 to 100°C. Accurate measurements of sodium flow rate were made with an Inconel venturi meter which was designed for a maximum flow rate of 15 gpm with a differential heat of 48 in. of sodium at this maximum flow rate. Water and the weigh tank method of calibration were used to calibrate the venturi meter. The differential pressure between inlet and throat of venturi meter was measured by manometer columns and differential transformers. An Engineering Sodium Test Loop was used for the experimental calibration of the magnetic flowmeter. The experimental accuracy of this work is better than 1%. The theoretically predicted value of the calibration factor was always found to be within at least 3% of the experimentally determined value. (auth)

**1674** (K-L-6134) MULTIBULB VISCOMETER OPERATION AND MAINTENANCE MANUAL. Kermicle, H. A.; Stevens, R. H. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Nov. 11, 1966. Contract W-7405-eng-26. 10p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

A semiautomatic glass viscometer, which is a three-bulb instrument for determining the efflux time of a liquid at three different consecutive shear rates, is described. Data are obtained by measuring the time required for the sample level to fall between a pair of meniscus detectors located above and below each bulb along a vertical tube. The different shear rates are accomplished by the vertical spacing of the bulbs which results in a different liquid head pressure exerted across the flow resistance at each bulb level. The bulb volumes are selected to provide approximately equal meniscus transit times for water as the liquid lead decreases. Flexible fiber optic tubes illuminate the meniscus at each detector and conduct the reflected light to a bank of photoconductive cell detectors. Solid state circuitry actuates separate precision clock timers for each of three glass bulbs in the unit. The efflux times are stored on the clock faces until reset by the operator. (auth)

**1675** (N-66-22344) DEVELOPMENT OF ELECTRICAL SWITCHGEAR FOR SPACE NUCLEAR ELECTRICAL SYSTEMS. Quarterly Progress Report No. 5, December 4, 1965-March 4, 1966. Powell, A. H. (ed.) (General Electric Co., Cincinnati, Ohio. Missile and Space Div.). 1966. Contract NAS3-6467. 54p. (NASA-CR-54924). CFSTI $3.00 cy, $0.50 mn.

The design and development of a ground prototype a-c circuit breaker and d-c engine contractor, suitable for, and tested under anticipated launch and space nuclear electrical system requirements, are described. Actuators for operating the vacuum capsule were assembled and placed in test; the interrupter units were trial assembled, and two vacuum capsules are in the process of being assembled. A check and bake-out of the endurance test oven was successfully completed. The vacuum interrupter includes a supporting shell, heat transfer and insulating parts, and terminals with current-carrying members to mount and attach the vacuum capsule. The capsule, the heart of the breaker and contactor, and the supporting members (interrupter unit) are discussed. Photographs of the testing oven, interrupter unit, vacuum capsule, ion pump, and other electrical switchgear units are presented. Along with several schematic diagrams and calibration curves. (STAR)

**1676** (RISO-M-445) PALIDELIGHED AF GLOEDELAMPER I ALARM PANELER. (Test of Indicator for Signal Lights in Alarm Panels). Timmermann, Povl (Danish Atomic Energy Commission, Risoe. Research Establishment). Aug. 1966. 4p. Dep. mn.

Some data on failure rates and lifetimes are given for signal lamps together with recommendations for use and testing of alarm annonciators. (auth)

**1677** (UCID-15023) FREQUENCY DOMAIN COMPENSATION OF COAXIAL CABLES FOR BEST TIME DOMAIN RESPONSE. Peterson, Roger L. (Lawrence Radiation Lab., Univ. of California, Livermore). June 17, 1966. Contract W-7405-eng-48. 45p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Until the advent of extensive nuclear testing, broad-band losses in coaxial cable transmission systems were ignored. Most applications of such cable prior to testing were concerned with the absolute attenuation of narrow, band-limited signals. Most of the signals encountered in nuclear testing are single pulses having comparatively short risetimes. The frequency response of the transmission system is of interest from dc to approximately one Gc. This report is concerned with compensation in the frequency domain of the attenuation characteristics of high-quality coaxial cable of the type currently used in the field. In order to get an idea as to the problems involved in compensating such a cable, a piece of $\frac{7}{8}$-inch Styroflex, 1011 feet long was obtained, tested and a compensator was built. Results of this experiment have led to more general conclusions about cable testing and compensation. (auth)

**1678** (UCRL-14930-T) DETERMINATION OF CHARGE SENSITIVITY OF A TUNNEL DIODE VOLTAGE THRESHOLD DISCRIMINATOR USED IN TIME DIFFERENCE MEASUREMENTS. Compton, P. D. Jr.; Johnson, W. A. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 10, 1966. Contract W-7405-eng-48. 30p. (CONF-661020-1). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From 13th Annual Nuclear Science Symposium, Boston, Mass.

The results of an investigation of the delay time variation of a tunnel diode (TD) threshold sensing discriminator are presented. These variations are a function of the square root of the input signal risetime and are accountable in terms of a charge sensitivity of the tunnel diode. A distinction is made between the charge sensitivity due to continuously rising signals and that due to short, low-energy pulses. A simple experimental method used for measuring the delay time variation as a function of the input signal risetime is described. The method is quite general and may be applied to any type of threshold discriminator. A theoretical model of the tunnel diode operating in the discriminator mode is developed. An equivalent circuit approach is used in this development by considering three phases of operation; before the TD reaches threshold, during the actual TD switching, and after the TD has fired. The model agrees with the experimental data, and it is concluded that the charge sensitivity model is a usefully valid concept which is applicable to the design and prediction of discriminator time-delay characteristics. (auth)

**1679** (UCRL-70011(Rev.1)) DECOUPLING TRANSFORMER FOR HIGH ENERGY PULSE SHAPING. Aaland, K.; Zucker, O. (California Univ., Livermore. Lawrence Radiation Lab.). July 18, 1966. Contract W-7405-eng-48. 31p. (CONF-661016-18). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Symposium on Engineering Problems of Controlled Thermonuclear Research, Gatlinburg, Tenn.

A unique saturating pulse transformer was designed which, when inserted between a capacitor bank and an inductive load, will produce a trapezoidal current waveform resulting from the fact that transformer action actually ceases for a prescribed period of time once a desired level of current is attained. After a primary half-cycle ringing period, transformer action again resumes in the reverse direction, with the load current returning to zero. That development was described by K. Aaland in a paper entitled Saturating Pulse Transformer with Optimized Output for a Solenoid Load (UCRL 14511-T) which discusses the design of an actual transformer built. An analytical treatment of such a trapezoidal-pulse-producing transformer is presented. It begins by presenting some insight into the effect of saturation upon a ferromagnetic core. Then an assumption is made that there actually exists a transformer which will decouple upon saturation, whereupon, an analysis is made of a circuit utilizing such a transformer to couple a charged capacitor to an inductor, showing that the output current is one which would be desirable for many short duration, constant current requirements. Then the calculation of the parameters involved (i.e., capacitance, primary saturation inductance and the core volt-second product) for obtaining a specified output are made. Next, the explanation of the decoupling mechanism is presented. Finally, the steps taken in the design of an actual transformer specifying dimensions that will have the specific features arrived at previously is presented and an explanation of why a one-turn primary/secondary configuration for the transformer is used is shown, despite the fact that such a set-up necessitates the use of a very large, heavy iron core. A discussion of several refinements to the design is also included. (auth)

**1680** 400-CHANNEL PULSE-HEIGHT ANALYZER. Kikuchi, Kunitaro; Yoshida, Tomio (Matsushita Electric Industries Co., Ltd, Osaka). Nat. Tech. Rep. (Matsushita Elec. Ind. Co., Osaka), 11: 311-19(Oct. 1965). (In Japanese).

An all-transistorized 400-channel pulse-height analyzer, operable by a push-button system on the front panel, was recently constructed in trial. This analyzer consists of a linear amplifier system, analog-digital converter system, computing system, and control system, utilizing the recent analog, digital and electronic-computing techniques, and ferrite core memory elements. The two-stage doublet linear amplifier system has a multiplication factor of 100. The analog-digital converter system is composed of a pulse height-pulse width converter circuit and clock pulse genera-

tor circuit (flip-flop type, 5 Mc.). The computer system is composed of a pulse scaler, scale-10 memory-circuit ($20 \times 20 \times 24$ ferrite core elements (1.27$\phi$)), switch core closing-and-opening circuit and sense amplifier circuit. The control system is composed of a mode-signal generator and control network, and is so constructed as to permit a selection for the following four operational modes: analysis, display, readout and stop modes. Other specifications of the analyzer are as follows: memory capacity, $10^6$/channel; dead time, 0.2N + 10 $\mu$sec. (N is the channel number); drift, 1 channel/day; linearity, ±0.5% max. in the full scale; input impedance, 500Ω or 4 kΩ; electric power required, 50–60 c/s., 100 V., 36 W.; dimensions, $26 \times 22 \times 54$ cm; weight, 16 kg. (NSA of Japan)

**1681** DIRECT-CURRENT-COUPLED PULSE AMPLIFIER CIRCUIT. Patzelt, R.; Kospach, K. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 374-6(1966). (In German).

In tenfold amplification and a rise time of less than 20 nsec the input and output lies at 0 voltage and the supply range is ±10v. The effects of temperature and counting rate oscillations are therefore suppressed. The circuit is suitable especially for the construction of multistage overmodulated amplifiers for nuclear physics purposes with permanent direct current coupling. (tr-auth)

**1682** EMITTER CURRENT REGULATOR FOR MASS SPECTROMETERS. Buschbeck, F. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 382-6(1966). (In German).

An emitter current regulator, which gives to the ion source a predetermined heating voltage, was constructed for an electromagnetic mass spectrometer. The advantage of this installation with respect to the usual methods are discussed. (tr-auth)

**1683** METHOD FOR SYSTEMATIC NOISE REDUCTION IN ELECTRONIC EQUIPMENT FOR NUCLEAR PHYSICS. Felber, H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 397-9(1966). (In German).

A method is given for the systematic noise reduction in electronic equipment. The elimination of pulses originating from the power supply, pulses originating from electromagnetic interspersion, and impulses caused by collision discharges on high-voltage condensers are eliminated separately. (J.S.R.)

**1684** 100-MHz SCALER. Attwenger, W. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 407-10(1966). (In German).

The 100-MHz tunnel diode scaler circuit with 16-fold reduction consists of three units: input stage, reduction chain, and output stage. The operation and results of each were described. (tr-auth)

**1685** HIGH-SENSITIVITY AMPLIFIER FOR DIGITAL MAGNETIC-TAPE INSTRUMENT. Attwenger, W.; Petreczek, K. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 411-13(1966). (In German).

In reading digital information of slow running magnetic tapes, head voltages of 100 $\mu V_{ss}$ occur. Two different amplifier circuits with low input resistance and good suppression of equal phase signals were described. (tr-auth)

**1686** DEVICE FOR MEASURING NUCLEAR MAGNETIC RESONANCE IN FLUID FLOW. Rukhin, A. B.; Pavlov, O. V., Ekaterinin, V. V. Izv. Akad. Nauk Kaz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 69-75(Apr.-June 1966). (In Russian).

An NMR installation consisting of a hydraulic and a magnetic system along with an NMR signal detection block is described. The results of some basic tests of the detector are given. It is found that the ratio $\omega_0/\bar{\omega}$ as a function of the Reynolds number in a stabilized hydrodynamic velocity profile in a weak magnetic field agrees with the universal $\omega_0 = 2\bar{\omega}$. (G.O.Y.)

**1687** NONRESONANCE INVERSION OF NUCLEI IN FLUID FLOW. Polyakov, A. I.; Yakovlev, G. I. Izv. Akad. Nauk Kaz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 61-8(Apr.-June 1966). (In Russian).

The design and operation of a maser for measuring fluids by the method of nonresonance inversion of nuclei are described. (R.V.J.)

**1688** THIN-WALLED TARGET WITH LIQUID HYDROGEN. Smolyankina, T. G.; Radkevich, I. A.; Sokolovskii, V. V. (Inst. of Theoretical and Experimental Physics, Moscow). Prib. Tekh. Eksp., No. 3, 208-9(May-June 1966). (In Russian).

A thin-walled target with liquid hydrogen for particle outlet was described. (tr-auth)

**1689** REFINEMENT OF MI-1305 MASS SPECTROMETER FOR ISOTOPIC ANALYSIS OF NATURAL CARBON AND OXYGEN. Matush, L.; Opauski, I.; Kish, I. (Central Research in Physics, Budapest). Prib. Tekh. Eksp., No. 3, 158-60(May-June 1966). (In Russian).

For study of the origin of natural sources of $CO_2$ and determination of paleotemperatures, the measurement of the ratios $^{13}C/^{12}C$ and $^{18}O/^{16}O$ with high precision is necessary. For this purpose the MI-1305 mass spectrometer was refined: a new gas input system was used; the ion collector was reconstructed so that the distance between the apertures, serving for the passage of two comparative ion beams, precisely equaled the differences of the mass number; for compensation comparison of the ion current a sensitive recording device was used; precise control of the accelerating ion voltage and of the stability of the magnet feed was introduced. (tr-auth)

**1690** MULTICHANNEL COMPUTING SYSTEM BASED ON AI-100 ANALYZER FOR MEASURING YIELDS OF PHOTONUCLEAR REACTIONS. Balamatov, N. N.; Goryachev, B. I. (Moscow State Univ.). Prib. Tekh. Eksp., No. 3, 88-93(May-June 1966). (In Russian).

The system was developed based on the AI-100 analyzer permitting, through complex apparatus for multichannel methods of measuring the yield curves of photonuclear reactions, the exchange of multichannel counter systems and commutating installations. The changes introduced in the AI-100 scheme permit the use of the analyzer in three operations: multichannel counter system, amplitude analyzer, and counter analyzer (analyzer of numbers). The principal tasks of the system are described and the basic principles of the installation are given. The resolving time of the counting system is ~1 $\mu$sec. (tr-auth)

**1691** ELECTRON-COMPUTER FREQUENCY STABILIZING SYSTEM FOR HIGH-FREQUENCY GENERATORS. Denisov, Yu. N.; Komissarov, A. G.; Prilipko, V. I.; Susov, Yu. I.; Shishlyannikov, P. T. (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp., No. 3, 107-14(May-June 1966). (In Russian).

The apparatus permitting automatic adjustment and maintenance of assigned frequency of hf generators with a precision of $10^{-3}$% in the frequency range from 1 to 100 MHz was described. (tr-auth)

**1692** NANOSECOND PULSE BRANCHING DISCRIMINATOR. Vovchenko, V. G.; Shchetkovskii, A. I. (Inst. of Physics and Tech., Leningrad). Prib. Tekh. Eksp., No. 3, 141-2(May-June 1966). (In Russian).

The design of the pulse branching discriminator for signals, operating during conversion of the output amplitude to two series of 0.1 to 20 V, was examined. The size of the output signals does not vary more than 40%. The discriminator forms pulses with duration of 6 to 10 nsec, which are divided into four channels. The dead time of the discriminator is 20 nsec. (tr-auth)

**1693** BOMBARDMENT-FREE MICROWAVE WAVEGUIDE WINDOW. Vural, Bayram (to U. S. Atomic Energy Commission). U. S. Patent 3,289,122. Nov. 29, 1966.

A waveguide window is designed wherein bombardment of the window by charged particles is minimized by the configuration of the waveguide walls in the vicinity of the window. The window is mounted within a support waveguide section. Each end of the section connects abruptly to a transverse surface which in turn connects to a large diameter waveguide section that is tapered to connect with the main waveguide. The abrupt junction of the support waveguide and the transverse surface causes an electromagnetic field to be developed which is away from the window. The tapered surface causes another electromagnetic field to be developed which is towards the window. The force away from the window is greater than the force towards the window. This results in a net force that causes charged particles to accelerate away from the window. (AEC)

**1694** DEVICE FOR CONCENTRATING X-RAYS AND OTHER RADIATION. Franks, Albert (to National Research Development Corp.). British Patent 1,047,596. Nov. 9, 1966. Filed Aug. 27, 1962.

A device is described for concentrating x rays and particles having an equivalent DeBroglie wavelength, e.g., neutrons. The device comprises a series of reflecting surfaces closely spaced in cross section in any plane or planes in which the rays are to be concentrated, are each shaped in said plane or planes to a smooth curve the tangents at the ends of which are substantially parallel to the required directions of the rays on the opposite sides of the device, while the curve joining the tangents is sufficiently gentle to produce multiple reflections along the curve from the one end to the other. (B.G.D.)

**1695** DISC-LOADED WAVEGUIDE TUNING MACHINE WHICH AUTOMATICALLY TUNES SUCCESSIVE CAVITIES BY INDENTING WAVEGUIDE WALL. Heinz, Marvin L. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,672. Nov. 22, 1966.

A machine is designed for tuning individual cavities of a disc-

loaded waveguide section to a selected resonant frequency. Two opposing pairs of hydraulic rams are provided which have indenting tips lying along a diameter of the waveguide section in a plane transverse to the axis of the section and spaced 90° apart therearound. The midpoints of the cavities of the waveguide section are successively positioned opposite the indenting tips. Radio-frequency power is applied to each cavity when it is so positioned and the signal generated thereby is measured. The hydraulic rams are then actuated to drive the indenting tips against the cavity wall a distance proportional to the measured signal thereby permanently adjusting the cavity dimensions so as to tune the cavity to the selected resonant frequency. (AEC)

**1696** PERIOD METER AND LOGARITHMIC RATE METER. Vincent, Charles Holmes; Rowles, John Brian (to United Kingdom Atomic Energy Authority). British Patent 1, 045,975. Oct. 19, 1966. Filed June 28, 1963.

A period meter and a logarithmic ratemeter are designed for reactivity measurements in a nuclear reactor. The period meter comprises a digital scaler means for counting input pulses occurring in successive time intervals. An immediate reading of the inverse period can be obtained at the end of each counting interval, with nearly maximum accuracy statistically possible. (L.B.S.)

**1697** PULSE TIME DELAY CIRCUIT EMPLOYING TUNNEL-DIODE AND SWITCH COMBINATION GATED IN RESPONSE TO RAMP INPUT. Kerns, Q. A.; Birk, M.; Nunamaker, T. A. (to U. S. Atomic Energy Commission). U. S. Patent 3,284,642. Nov. 8, 1966.

A continuously variable electronic delay circuit is designed, which can receive up to three million pulses per second and in which a one volt change in a control potential will change the delay time by 160 picoseconds. It is possible to continuously vary the delay time of the pulses by varying a control potential. Upon receipt of an input pulse, a current ramp is applied to a tunnel diode circuit. When the tunnel diode shifts to the higher voltage state an output pulse is produced which has been delayed by the time period the tunnel diode is in the lower voltage state. Special circuit means rapidly return the tunnel diode to the quiescent lower voltage. (AEC)

**1698** ATTENUATOR FOR SUPPRESSING HIGH-ORDER CAVITY RESONANCES HAVING A TRANSVERSE ELECTRIC COMPONENT. Hammersand, Fred G. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,673. Nov. 22, 1966.

An attenuator mounted in a resonant cavity of a klystron tube is designed for suppressing spurious cavity resonances at or near the third harmonic of the tube operating frequency. The attenuator comprises a plurality of shorted loops of lossy metal secured in nonsymmetrical orientation around the inside surface of the cavity with all of the loops in a plane perpendicular to the axis of the klystron tube. (AEC)

## Radiation Effects on Instruments and Instrument Components

*Refer also to abstract 2290.*

**1699** (AD-632458) INVESTIGATION OF TRANSIENT RADIATION DAMAGE IN SEMICONDUCTOR MATERIALS. Quarterly Progress Report No. 1, October 1–December 31, 1965. Corelli, John C.; Frederickson, A. Robb (Rensselaer Polytechnic Inst., Troy, N. Y.). May 1966. Contract DA-28-043-AMC-01788(E). 15p. (ECOM-01788-1). CFSTI $1.00 cy, $0.50 mn.

First results are given of transient radiation damage experiments designed primarily to cover a wide range of electron flux (about $10^5$ to $10^{10}$ e/cm$^2$ in the pulse). The incident electron energy was 48 MeV and the electron beam pulse widths used were in the range 1 to 4.5 microsec. The samples studied were 100 ohm-cm floating zone silicon, phosphorus and indium doped. The irradiations were carried out with the sample at 100, 200, or 300°K to roughly check temperature dependence. The probes used to detect transient radiation damage are the conductivity and Hall effect voltages. The results indicate a saturation in the Hall effect and conductivity voltage pulses for electron fluxes $\geq 10^9$ e/cm$^2$. Both the fractional Hall effect and conductivity voltages (delta V/V) have the same flux dependence. The main effect in transient radiation damage experiments is one of ionization and recombinations of excess electron hole pairs, and moreover transient atomic displacement damage if present is small and not detectable. (auth)

**1700** ANALYSIS OF THE EFFECT OF FAST NEUTRON BOMBARDMENT ON THE CURRENT-VOLTAGE CHARACTERISTICS OF A CONDUCTIVITY-MODULATED P-I-N DIODE. Swartz, John Michael. Columbus, Ohio, Ohio State Univ., 1965. 59p.

Thesis.

Fast neutron bombardment of silicon diodes changes the excess carrier diffusion length without significantly changing other diode parameters. Such bombardment is thus a useful tool for investigating diode theory. The technique is applied to an expression for the current-voltage characteristic developed for the wide-based p-i-n diode. For high level injection, there are two current density ranges of interest. First, a range where the base voltage is independent of current density and the total junction voltage, V, varies as exp (qV/2k T) with current. This region corresponds to unity emitter efficiency at each of the junctions. For higher current densities, the emitter efficiency decreases, and the base voltage increases as the square root of the current density. Also, the total junction voltage varies as exp (qV/kT) with current. The theoretical results are then shown to fit the current-voltage characteristics of experimental wide-based silicon p-i-n diodes. (Dissertation Abstracts)

**1701** SPACE-RADIATION EFFECTS IN INTEGRATED CIRCUITS. Hamman, Donald J. (Batelle Memorial Inst., Columbus, Ohio). 13p. (CONF-660705-7). ORAU. Gmelin, AED-CONF-66-222-12.

From IEEE Annual Conference, Palo Alto, Calif.

The damage mechanisms in semiconductors from space radiation and the effects on the microcircuit elements and the microcircuit parameters are discussed. Some tabular data are presented and a general-effects summary and some design considerations are included. (auth)

**1702** TRANSIENT RESPONSE OF MOS TRANSISTORS AND INTEGRATED CIRCUITS TO IONIZING RADIATION. Long, D. M.; Flescher, H. L. (Martin Co., Baltimore). 6p. (CONF-660705-9). ORAU. Gmelin, AED-CONF-66-222-11.

From IEEE Annual Conference, Palo Alto, Calif.

The following conclusions were obtained from a study of transient radiation effects phenomena on MOS transistors and integrated circuits. The dominant response mechanisms for Sprague MOS transistors packaged in nitrogen encapsulated TO-5 cans have been identified as: radiation induced leakage from a lead to the case due to ionization of the encapsulated gas, and the primary photocurrent of the drain-substrate p-n junction. The ionization-induced leakage can be reduced considerably by using air or paraffin as an encapsulant or by using a smaller package. For Sprague p-enhancement transistors, the two identified mechanisms are sufficient to explain all observed responses at various load and bias conditions. For Sprague n-depletion transistors, however, additional response mechanisms must yet be identified to fully explain the observed response. The additional response mechanism(s) is believed to be associated with carrier generation in the channel region and, in the active region, the additional drain current can be explained as a transient change in the threshold voltage ($V_T$) of the device. The MOS digital integrated circuits which were tested exhibited transient radiation failure thresholds on the order of 10 to 100 R for radiation pulse widths less than the RC time constants of the circuits (typically, μsec). Both substrate photocurrents and the $g_m$ amplification of induced gate voltage changes are instrumental in causing failure in microcircuits. No latch-up phenomena were observed in any of the microcircuits tested. (auth)

**1703** RADIATION EFFECTS ON MONOLITHIC SILICON INTEGRATED CIRCUITS. Perkins, C. W.; Marshall, R. W. (Hughes Aircraft Co., Fullerton, Calif.). 30p. (CONF-660705-10). ORAU. Gmelin, AED-CONF-66-222-8.

From IEEE Annual Conference, Palo, Alto, Calif.

Both the transient radiation response and the permanent radiation damage of thirty-four types of monolithic integrated digital circuits were measured and the critical radiation thresholds for circuit failure were determined. A theory for the transient radiation response of OFF-gates is derived on the basis of primary photocurrent in the collector-substrate junction of the output transistor. From this theory the critical radiation thresholds can be predicted for circuit failure, which is defined in terms of circuit noise margin. The effects of fan-out are included in this theory, but it is shown that fan-in has no effect on the response. The theory is used to explain the qualitative features of the experimental results. The basic features of the transient radiation response of ON-gates are also examined and analyzed. It is demonstrated that the response of ON-gates can be eliminated by a proper choice of supply voltage and circuit design. A theory for permanent damage in monolithic integrated circuits is derived on the basis of existing theory of the degradation of current gain, $h_{FE}$, in transistors. From this theory the critical radiation threshold can be predicted for circuit failure which is defined in terms of the increase of the output voltage to levels above which noise

margin disappears. This theory is in agreement with the experimentally observed results. (auth)

**1704** RADIATION EFFECTS ON MICROCIRCUITS. Messenger, George C. (Nortronics, Newbury Park, Calif.). 42p. (CONF-660705-8). ORAU. Gmelin, AED-CONF-66-222-7.

From IEEE Annual Conference, Palo Alto, Calif.

A review is presented of experimental data on the transient radiation effects on a variety of contemporary microcircuits of various construction techniques. The experimental results are used as a basis for suggesting hardening techniques for the ionizing radiation environment, which include pulse compensation especially in the transistor base regions and the addition of internal memory elements to flip-flops. The present understanding of basic mechanisms is reviewed, both for neutron displacement damage processes and the creation of hole electron pairs due to ionizing radiation. (L.B.S.)

# LIFE SCIENCES

## Biochemistry, Physiology, and Molecular Biology

*Refer also to abstracts 1312, 1328, and 2827.*

**1705** (COO-1339-4) A STUDY OF FISSION PRODUCT LEVELS AND METABOLISM IN FOOD PRODUCING ANIMALS AS DETERMINED BY WHOLE BODY COUNTING. Summary Progress Report, December 1, 1963–August 15, 1966. (Illinois Univ., Urbana). Contract AT(11-1)-1339. 25p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Whole-body counting was used to determine the uptake and retention of $^{137}Cs$ in cattle, goats, sheep, and swine maintained on a diet containing various levels of $^{137}Cs$. Data are included on the $^{137}Cs$ content in cattle after intravenous or per os administration. A list of 8 publications issued during the period covered by this report is included. (C.H.)

**1706** (NYO-3364-22) THE CORRELATION BETWEEN THE PRECIPITATION AND THE CONCENTRATION OF $^{137}Cs$ IN COW'S MILK IN NORWAY. Madshus, Kjell (Norsk Hydro's Inst. for Cancer Research, Oslo); Stroemme, Aksel (Norsk Radiumhospital, Oslo). [1966]. Contract AT(30-1)-3364. 8p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The relationship of precipitation and the content of $^{137}Cs$ in milk in Norway was determined during the Spring months of 1966. Data are compared with results of measurements made during 1965. (C.H.)

**1707** (ORNL-3907) INCORPORATION OF A THYMIDINE ANALOG BY INDIGENOUS RODENTS. O'Farrell, Thomas P.; Auerbach, S. I.; Dunaway, P. B. (Oak Ridge National Lab., Tenn.). Mar. 1966. Contract W-7405-eng-26. 189p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Thesis. Submitted by Thomas P. O'Farrell to Univ. of Tennessee, Knoxville.

The thymidine analog 5-$^{131}$iodo-2′-deoxyuridine ($^{131}$IUDR) was administered to wild rodents, and the activity retained was measured in whole-body counters to test the potential of $^{131}$IUDR as an in vivo index to cell proliferation and DNA synthesis. Experiments were designed to characterize the tissue distribution of activity in order to test the usefulness of whole-body retention curves; determine the incorporation of $^{131}$IUDR by three species of rodents and relate their cell proliferation rates to general metabolic rates; and study the effects of acute gamma radiation on $^{131}$IUDR uptake to test whether whole-body curves of activity retained could be used as physiological dosimeters. (C.H.)

**1708** (ORO-3488-1) THE BIOGEOCHEMICAL CYCLE OF $^{134}Cs$ IN TWO NATIVE STANDS OF ANDROPOGON SCOPARIUS MICHX. Dodd, J. D. (Texas Agricultural Experiment Station, College Station). Aug. 15, 1966. Contract AT(40-1)-3488. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A study to compare the distribution of the radionuclide $^{134}Cs$ in two native grasslands on different soil types was initiated the spring of 1966. Injections of 200 uc of $^{134}Cs$ in 0.1 ml of solution using a needle and syringe were made into the base of a green culm on 20 selected crowns of a variety of Andropogon in each soil type. Initial distribution through the crown was slow, apparently due to unseasonably cool weather conditions. A completely uniform distribution was not evident, particularly in the clay soil. Litter samples from near the treated crowns all contained the radionuclide with the highest concentration from the region of injection. Species other than those injected showed varying amounts of activity. In general, perennial plants 105 cm away from the treated crowns, regardless of soil type, contained some activity and distribution of $^{134}Cs$ through the soil compartment was rapid. Next to the treated plants, it occurred at depths in excess of 27.5 cm, regardless of the soil type. Horizontally the spread was from approximately 90 to 105 cm from the treated crowns. As the distance increased, the depth and activity decreased. However, the radionuclide was generally distributed deeper in the clay soil away from the plant. Root samples from the sandy soil showed decreasing activity with increasing depth while this trend was not evident in the clay site. Activity was consistently present in dew, throughfall, and washings from leaves. (C.H.)

**1709** (TID-23265) RADIATION EFFECTS IN BIOCHEMISTRY AND ORGANIC CHEMISTRY. Technical Progress Report, October 15, 1965–October 14, 1966. (Colorado Univ., Boulder). Contract AT(11-1)-690. 133p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Results are presented from studies on the effects of ionizing radiation in purified compounds found in biological systems, with emphasis on solid amino acids, peptides, and proteins. Data are included on the effects of $^{137}Cs$ $\gamma$ radiation on the denaturation of $\alpha$-chymotrypsin; mechanisms of radioinduced denaturation of enzymes; the relationship of stable free radicals to radiation damage in lysozyme; hydrogen exchange in lysozyme; $\gamma$ radiation effects on reversible configurational damage in lysozyme determined by tritium exchange methods; energy transfer during the $\gamma$ inactivation of the allosteric, oligomeric enzyme aspartate transcarbamylase (ATCase); the effects of $\gamma$ radiation on the allosteric properties of hemoglobin; the effects of $\gamma$ radiation on the activity of dehydrogenase enzymes and radiation energy transfer in several dehydrogenase enzymes; and the $\gamma$ induced decarboxylation of DL-phenylalanine at low energy inputs. A list is included of 28 publications since 1964. (107 references.) (C.H.)

**1710** (CEA-tr-A-1880) TAUX DE $^{90}Sr$ ET DE $^{137}Cs$ DES BREMES DES EAUX TERRITORIALES DE L'ALLEMAGNE DU NORD. (Contents of $^{90}Sr$ and $^{137}Cs$ of Bream of Territorial Waters of North Germany). Feldt, W.; Lange, J. Translated into French from Z. Lebensm.-Untersuch.-Forsch., 117: 103-13 (1962). 30p. Dep. mn. JCL $2.60 fs, $1.10 mf.

The contents of $^{90}Sr$ and $^{137}Cs$ in breams from flowing and still waters of north Germany were studied. The fish from still waters have a higher degree of contamination than the fish from the Elbe. This is especially valid for $^{137}Cs$. The $^{90}Sr$ is accumulated preferentially in the organs rich in calcium (bones), but the $^{137}Cs$ appears principally in the organs rich in potassium (muscles). The values of $^{90}Sr$/g Ca and of $^{137}Cs$/g K in the organism are subject to fluctuations. (tr-auth)

**1711** SENSITIVITY OF THE PHAGE AND COMPLEMENTARY STRANDS OF THE REPLICATIVE FORM OF PHAGE $\varphi$ X 174 DEOXYRIBONUCLEIC ACID TO ULTRA-VIOLET LIGHT. Iliashenko, B. N. (Gamaleya Inst. for Epidemiology and Microbiology, Moscow). Nature, 211: 430(July 23, 1966).

The ultraviolet inactivation of the infectivity of both chains of DNA from RF$\varphi$X 174 phage was investigated. Data showed that thymine plays an active part in the formation of lethal ultraviolet lesions. The sensitivity of the two polynucleotide chains in the RF DNA molecule to ultraviolet was correlated with thymine content. Only about 40% of the lethal lesions resulted from thymine dimerization. (H.G.D.)

**1712** REPARATIVE SYNTHESIS OF DNA AFTER X IRRADIATION. Smets, L. A.; Dewaide, H. (Univ. of Nijmegen, Netherlands). Naturwissenschaften, 53: 382(1966).

Monolayer cultures of bovine liver cells were synchronized with 5mM thymidine for 24 hr followed by a recovery period of 2 hr in normal medium. Part of the cells were exposed to 400 R x radiation and all cells were cultivated in the presence of colchicine and $^{32}P$ during the next 24 hr. Radiography after treatment with $^{3}H$-thymidine revealed that at the moment of irradiation 77% of the cells were synthesizing DNA and no mitotic figures were observed at that time. Twenty-four hrs after irradiation 96 to 98% of the cells were undergoing mitosis, measurements of the DNA content of irradiated and control cells showed that the DNA was distinctly higher in irradiated cells. It is concluded that a reparative synthesis of DNA occurred after irradiation. (C.H.)

**1713** EFFECT OF WHOLE-BODY IRRADIATION WITH $^{60}Co$ ON PLACENTAL GLYCOGEN OF THE RAT. Sciascia, R.; Ruggeri, F. (Univ., Bologna). Boll. Soc. Ital. Biol. Sper., 42: 135-6 (Feb. 15, 1966). (In Italian).

Earlier studies showed that $\gamma$ irradiation decreased glycogen content of liver without affecting the content in vagina and bladder epithelium of pregnant rats. In the present experiments, Sprague-Dawley rats on the 14th day of gestation received 1000 R, whole-body doses of $^{60}Co$ $\gamma$ radiation. This time was chosen because glycogen content of placenta reaches a maximum between the 13th and 15th days of pregnancy. Rats were sacrificed 2, 4, 8, 24, 48, and 70 hr post-irradiation; the placentas were frozen immediately in dry ice, sectioned, and stained for glycogen by the periodic acid-Schiff and Alcian blue technics. Glycogen distribution was similar in control and irradiated rats. Decidual cells were heavily stained for glycogen in both instances; it was present also in the spongiotrophoblast layer. No quantitative change was noted in placental glycogen in the irradiated rats compared with controls although liver glycogen content was clearly decreased 2 hr postirradiation. The results demonstrate the different response of glycogen to irradiation in different organs. It is suggested that liver glycogen may be more readily depolymerized by irradiation in liver than in other tissues. (BBB)

**1714** HEMATOPOIETIC TISSUE NEOPLASMS IN ANIMALS ADMINISTERED $^{90}Sr$. McClellan, R. O. (Battelle-Northwest, Richland, Wash.). Health Phys., 12: 1362-5 (Sept. 1966).

Miniature swine were fed strontium-90 daily in various doses for three generations. Five cases of neoplasms of the hematopoietic tissue developed. Factors involved in neoplasm development here rather than in bone are considered. These early results are compared with those previously reported for similar studies on swine and dogs. (C.O )

**1715** IRON UPTAKE AND TRANSLOCATION BY TOMATO PLANTS AS INFLUENCED BY ROOT TEMPERATURE AND MANGANESE NUTRITION. Riekels, Jerald W.; Lingle, John C. (Univ. of California, Davis). Plant Physiol., 41: 1095-1101(Sept. 1966).

The uptake of iron (Fe) by VF-36 tomato plants as influenced by root temperature and manganese (Mn) nutrition was studied. Following a 1-week pretreatment period of various levels of Fe and Mn in the nutrient solution in a controlled temperature room, the uptake of $^{59}Fe$ from ferric ethylenediamine di(O-hydroxyphenylacetate) (FeEDDHA) at 1 μmole per liter was studied for periods of 1 to 5 days. Both Fe uptake and translocation were enhanced by increases in root temperature. Varied levels of Fe in the pretreatment period led to increased levels of Fe in the plant, which subsequently depressed further accumulation of $^{59}Fe$. The effect of increased root temperature on $^{59}Fe$ uptake and translocation was decreased by increases in the level of Fe in the pretreatment cultures. As Mn in the nutrient solution was increased, $^{59}Fe$ uptake and translocation were increased to a point and then decreased. The degree of Fe saturation of the plant appeared to be a primary factor in regulating Fe uptake and translocation in the plant. As the Fe saturation of the plant decreased, the uptake of Fe in response to metabolic processes of the plant increased, as evidenced by increased response of absorption to root temperature. (auth)

**1716** DIRECT AND $^{18}O$-EXCHANGE MEASUREMENTS RELEVANT TO POSSIBLE ACTIVATED OR PHOSPHORYLATED STATES OF MYOSIN. Sartorelli, L.; Fromm, H. J.; Benson, R. W.; Boyer, P. D. (Univ. of California, Los Angeles). Contract AT(11-1)-34. Biochemistry, 5: 2877-84(Sept. 1966).

A careful search was made for a covalently linked phosphoryl group in myosin which has cleaved one $AT^{32}P$ per mole in a burst reaction. No evidence for a phosphoryl myosin was obtained upon extraction of protein with phenol near neutral pH, or by measurement of $^{18}O$ incorporation into inorganic phosphate ($P_i$) formed when trichloroacetic acid–$H^{18}OH$ was used to stop adenosine triphosphate (ATP) hydrolysis. Further, with EDTA or phenol as stopping agents in the presence of $H^{18}OH$, lack of appreciable $^{18}O$ incorporation into $P_i$ does not support possible presence of a labile acyl phosphate. When the burst reaction is carried out in $H^{18}OH$, the initial $P_i$ formed shows extensive exchange with water oxygen. In continued hydrolysis, water oxygen appears exclusively in the $P_i$ and not in the adenosine diphosphate (ADP) formed or in the unhydrolyzed ATP. Presence of 2,4-dinitrophenol slightly accelerates the oxygen-exchange reaction, but the p-mercuribenzoate inhibits the exchange. This p-mercuribenzoate inhibition appears distinct from the activation of adenosine triphosphatase (ATPase) by the mercurial. (auth)

**1717** CONTRIBUTION TO THE INVESTIGATION OF TRANSCUTANEOUS RESORPTION OF RADIOCERIUM ($^{144}Ce$). Frankovic, S.; Milosevic, Z.; Begovic, J. (Inst. for Application of Nuclear Energy in Agriculture, Veterinary Medicine, and Forestry, Belgrade). Acta Vet. (Belgrade), 15: 203-7(1965). (In Serbian).

Investigations were performed on white rats aged six months with the skin contaminated by $^{144}Ce$ in the form of $^{144}CeCl_3$ (pH 4.2) administered by dropping it on the dorsal surface of the right posterior extremity. Autohistoradiograms of the section of contaminated skin showed homogenous distribution of activity on epidermis and hair cover. On the sections taken thirty minutes after contamination, activity was found in the acini of sweat and tallow glands and the blood vessels. (JPRS)

**1718** NUCLEIC ACID SYNTHESIS IN X-IRRADIATED THYMOCYTES. Myers, D. C.; Skov, Kirsten (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Biochem., 44: 839-52(1966). (AECL-2434).

The rate of incorporation of thymidine into the deoxyribonucleic acid (DNA) of rat thymocytes in vitro was not immediately affected by low doses of x radiation, but became progressively more inhibited as the irradiated cells were incubated at 37°C for periods of up to 6 hours. Ribonucleic acid (RNA) synthesis deteriorated almost at the same rate as DNA synthesis after x irradiation in vitro, but protein synthesis was slightly more resistant. Addition of 10–50 mM nicotinamide to the irradiated cell suspensions tended to retard the development of this inhibition, particularly at low temperatures, but high concentrations of nicotinamide were also toxic to these cells. The inhibition of DNA synthesis by x irradiation appeared to follow a qualitatively similar pattern in thymus, spleen, and regenerating liver in vivo. In addition to the inhibition resulting from degenerative processes in the irradiated cells, DNA synthesis in vitro was directly inhibited by 20–30 kr x radiation. The effects of radiation on DNA synthesis paralleled to some extent its effects on the gel-forming capacity of the deoxyribonucleoprotein from the thymus cells. It is suggested that the normal synthesis of both RNA and DNA in thymocytes depends on the integrity of the deoxyribonucleoprotein. (auth)

**1719** SOME EFFECTS OF PERCHLORATE ON THE DISTRIBUTION OF $^{131}I$-IODIDE. Schoenbaum, E.; Sellers, E. A.; Gill, M. J. (Univ. of Toronto). Acta Endocrinol., 50: 195-201 (Oct. 1965).

In spite of a negligible uptake of radioiodine by the thyroid gland 48 hr after a tracer dose of $^{131}I$-iodide, the plasma $^{131}I$ count of the rats chronically fed a diet relatively low in iodine (0.25 μg/g) and containing 1.25% of potassium perchlorate was only 11% of that of the controls. This finding prompted a study of the effects of perchlorate on the distribution of $^{131}I$-iodide in rats. In rats receiving perchlorate the accumulation of radioactivity in the stomach, which occurred soon after $^{131}I$ injection in controls, was inhibited, and radioactivity in blood was higher in perchlorate-treated rats than in controls. After perchlorate, more radioactivity in kidney tissue and an elevated urinary excretion of the tracer were noted. After 24 hr, plasma radioactivity was lower in perchlorate-treated rats than in controls. Increased renal excretion of $^{131}I$ after perchlorate is, at least in part, due to higher blood radioactivity levels, probably because of decreased iodide space due to the action of perchlorate. These experiments do not provide information for or against the previous hypothesis that tubular reabsorption of iodide involves, possibly in addition to a passive process, an active transport mechanism capable of inhibition by perchlorate. They do illustrate the importance of extrarenal effects of perchlorate in explaining the increased renal excretion of a tracer dose of iodide which occurs during the administration of perchlorate. (BBB)

**1720** RADIOACTIVE IODOPROTEIN IN THYROID LYMPH AND BLOOD. Daniel, P. M.; Plaskett, L. G.; Pratt, O. E. (Univ., Edinburgh). Biochem. J., 100: 622-30(Sept. 1966).

Samples of thyroid and non-thyroid lymph and of thyroid and peripheral venous blood were obtained from primates and cats that had previously been given radioactive iodine. The distribution of the organic radioiodine between the protein and non-protein fractions in these samples was determined. The proportion of the organic radioiodine in the form of iodoprotein was assessed by paper chromatography, acid-ethanol precipitation, hot-butanol washing, column chromatography, and separate estimation of iodotyrosines after enzymic hydrolysis. In thyroid lymph the relative proportion of the organic radioiodine in the form of iodoprotein was 75 to 98%; in blood it was much lower, probably no more than 6 to 7%. The absolute concentration of iodoprotein radioactivity also was considerably greater in thyroid lymph than in blood. Enzymic hydrolysis of the protein of the thyroid lymph yielded a pattern of iodoamino acids that corresponded closely with that obtained after hydrolysis of protein extracted from the thyroid gland itself. It can be concluded that the iodoprotein in thyroid lymph consists mainly of thyroglobulin or a closely related compound. (auth)

**1721** EFFECTS OF HYDROBIOTITES ON $^{89}Sr$ ABSORPTION AND DEPOSITION IN CHICKS. Colvin, L. B.; Creger, C. R.; Couch, J. R.; Ansari, M. N. A. (Texas A and M Univ., College Station). Proc. Soc. Exp. Biol. Med., 122: 1262-4(Aug.-Sept. 1966).

Data from an investigation of oral administration of radiostrontium ($^{89}Sr$) to chicks indicates that feeding either untreated or acid activated verxite, a high purity hydrobiotite, is not effective in preventing absorption and deposition of radioactive strontium in the chick. (auth)

**1722** $^{137}Cs$ AND $^{85}Sr$ UPTAKE BY IRRIGATED AND MOUNTAIN RICE: STUDY OF THE RELATIVE IMPORTANCE OF PLANT VARIETY AND CULTURE MEDIUM. Myttenaere, C.; Masset, M. (EURATOM-CCR, Ispra, Italy). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-77/7, 32p. (In French). (CONF-660912-3). ORAU.

From FAO/IAEA Symposium on the Use of Isotopes in Plant Nutrition and Physiology Studies, Vienna.

The influence of the nutrient medium and plant variety on the uptake of $^{137}Cs$ and $^{85}Sr$ by rice was studied in two varieties (irrigated and mountain). The plants were grown in nutrient solutions with $^{137}Cs$ and $^{85}Sr$ added and in soil irrigated or surface-treated with the nutrient solutions. The effects of the $NH_4$, K, and Ca content of the nutrient solution on the uptake of $^{137}Cs$ and $^{85}Sr$ was also stud-

ied. After cultivation the plants were analyzed for the content of $^{137}Cs$, $^{85}Sr$, and stable elements in the various plant parts (roots, stems, and seed). Soil samples taken at various times during growth of the plants were also analyzed. Results showed that the nutrients in the medium, particularly the $NH_4$ ion, influenced the uptake of both $^{137}Cs$ and $^{85}Sr$ by rice. A marked difference in the uptake and distribution of the two isotopes in the two varieties was also found. Plants harvested from irrigated soil showed the greatest uptake of $^{137}Cs$. (C.H.)

**1723** THE UPTAKE OF RADIOACTIVE $^{89}Sr$ BY FORAGE PLANTS FROM SOILS OF SCHLESWIG-HOLSTEIN AND FROM MODEL SOILS. Schroeder, D.; Guenther, J. (Univ., Kiel). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-77/39, 16p. (CONF-660912-4). ORAU.

From FAO/IAEA Symposium on the Use of Isotopes in Plant Nutrition and Physiology Studies, Vienna.

Pot experiments were made in order to investigate the uptake of $^{89}Sr$ by rye grass and white clover from 19 soils varying in exchangeable calcium, pH, exchange capacity, and content of clay and organic matter. From the total $^{89}Sr$ given to each pot, 0.04 to 0.45% $^{89}Sr$ was found in one g of dry plant substance, with an average of 0.20% in rye grass and 0.25% in white clover. The $^{89}Sr$ content of the plants significantly increased with increasing amounts of exchangeable Ca, and decreased with increasing pH, exchange capacity, and clay content. Compared with the Ca content of the plants, the Sr content significantly decreased with increasing pH and exchangeable Ca, whereas there was no significant relation with exchange capacity, clay and peat content. Compared with the Sr/Ca ratio in soil mixtures, the corresponding ratio in clover decreased with higher pH. (C.H.)

## Ecology

**1724** (COO-1332-25) EFFECTS OF IONIZING RADIATION AND OTHER ENVIRONMENTAL FACTORS ON BREEDING BEHAVIOR, ACTIVITY PATTERNS, AND MOVEMENT OF SELECTED VERTEBRATES. Progress Report. Tester, John R. (Minnesota Univ., Minneapolis. Museum of Natural History). July 1966. Contract AT(11-1)-1332. 61p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Progress is reported on a study on the effects of ionizing radiation and other environmental factors on breeding behavior, activity patterns, and movement of selected vertebrates and possible effects on population dynamics. The LD50-30 for green-winged teal was determined to be 485 R $\gamma$ and the LD50-30 for shovelers was determined to be 894 R $\gamma$. Films and tape recordings made during social courtship of teals were analyzed to give information on the nature and extent of individual variations and variations correlated with age and season. An attempt to determine the immediate effects of 400 R and 600 R $\gamma$ radiation on courtship behavior was unsuccessful. Observations on shoveler males exposed to 400 R $\gamma$ radiation failed to reveal any effects of the radiation treatment on behavior. A total of 17 deer, 64 raccoon, and 15 snowshoe hares at the Cedar Creek Natural History Area near Minneapolis were radio-tagged and followed by an automatic radio tracking system. Data on movements, behavior, mortality, and population dynamics are presented. An adult male raccoon was exposed to 300 R $\gamma$ radiation and its movements and behavior post-irradiation were compared with those before exposure and with those of a control animal. Data are included from a comparison of the radiosensitivity of three species of ducks including the blue-winged teal, the green-winged teal, and shovelers. (73 references.) (C.H.)

**1725** (ORNL-3946) BIOCOENETIC PROCESSES IN AN ESTUARINE PHYTOPLANKTON COMMUNITY. Patten, B. C. (Virginia Inst. of Marine Science, Gloucester Point. Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 106p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

An ecological theory of adaptation at the community level of organization is developed. By adaptation is meant the establishment of optimum relationships between structure and function for community life under existing or expected conditions of environment. An analog computer model of a hypothetical food chain is explored to elucidate how structure-function relationships in coupled systems are determined by the communication net, or pattern of coupling between the parts. Since optimization necessarily implies input of information from the environment which details, in effect, how far off the present state of the system is from an optimum state, there is implicit in the adaptation process a kind of community cognition. To give emphasis to this aspect etymologically, the process of community adaptation is referred to as biocoenesis. An annual cycle of structure-function relationships in phytoplankton of the York River, Virginia, is described, with particular emphasis on aspects which relate to system adaptability. (auth)

**1726** CONTENT OF RADIOACTIVE STRONTIUM AND CESIUM IN THE ROOTS AND LEAVES OF VEGETABLES IN 1964, AND THE ECOLOGY OF THE PLANTS. Csupka, Stefan; Carach, Jozef; Petrasova, Maria (Krajska Station of Hygiene and Epidemiology, Bratislava). Biologia, 21: 432-7(1966). (In Czech).

The content of $^{90}Sr$ and $^{137}Cs$ of vegetables in Western Slovakia was investigated during 1964. During the spring season the vegetables contained nearly twice as much of the radioactive elements as during the fall. The leaves contained about 1½ times as much of the radionuclides as the roots. A daily intake of $^{90}Sr$ per inhabitant based on the consumption of vegetables averaged 2.8 pCi of Sr, and 4.2 pCi of $^{137}Cs$. (auth)

**1727** REGULARITIES IN THE BIOGENIC MIGRATION OF URANIUM. Kovalskii, V. V.; Vorotnitskaya, I. E. (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Moscow). Ukr. Biokhim. Zh., 38: 419-24(1966). (In Russian).

Data are presented on the biogenic migration of uranium in a medium with elevated and normal content of this element. Biogenic migration under dry-land conditions was studied in the system: soil–plant–animals. It is shown that uranium concentration by soils depends on the type of soil and the forms of the uranium compounds. Under conditions of elevated uranium content in the environment morphological variability was found in some plant species. The diurnal rations of uranium in farm animals are computed. Biogenic migration of uranium under conditions of an aquatic environment was studied in Lake Ussyk-Kul, the waters of which contain an elevated concentration of this element. It is shown that the uranium content and gradient of its accumulation in organisms with respect to water diminishes when uranium passes through the alimentary chain: algae → benthic and planktonic animal organisms → fish. (auth)

**1728** RADIOECOLOGY AND RADIOACTIVE POLLUTION OF THE ATMOSPHERE. Bocquet, H. (Commissariat a l'Energie Atomique, Paris). Prod. Probl. Pharm., 20: 59-80(Feb. 1965). (In French).

Because of his position at the top of the ecological pyramid, man is protected by various barriers occurring in the water-soil-plant-animal cycle, and by discriminatory factors in the food chain. If the increase in ambient radioactivity remains weak and slow, it is reasonable to expect that biological equilibrium will be maintained by adaptation. Irradiation of man by fallout is essentially of food origin, from incorporation into the food chain of the most critical nuclides, $^{14}C$, $^{131}I$, $^{90}Sr$, and $^{137}Cs$. Doses received are only a fraction of those from natural radiation and are considerably lower than those observed in special regions of strong natural radioactivity. Assuming a linear dose-effect relation, one may calculate the relative risks from artificial sources for genetic effects and somatic effects (leukemia and bone tumor, respectively) as follows: natural sources, 1, 1, 1; medical irradiation, 0.3, 0.4 to 0.8, ?; fallout to December 1961 excepting $^{14}C$, 0.04, 0.08, 0.12; $^{14}C$, 0.07, 0.07, 0.11. Long-term studies of ionizing radiation and its effect on man will give particular significance to irradiation equilibria in man and to radioprotection problems. (BBB)

## Genetics and Cytogenetics

**1729** THE EFFECT OF RADIATION DOSE RATE ON THE FREQUENCY OF CHROMOSOME ABERRATIONS INDUCED IN HUMAN LEUCOCYTES IRRADIATED IN VITRO. Wang, An-Ch'i; Chou, Hsien-t'ing; Ning, I-hua. Tung-wu Hsueh-pao, 18: 145-52 (June 1966).

According to the classical theory of radiation genetics, the dose-response curve for one-hit aberrations is linear and independent of the intensity or dose rate of radiation. However, in the case of two-hit aberrations, the frequency of aberrations increases with the square of the dose. Newcombe (1962) postulated that a break in a chromosome may restitue in a given period of time. The phenomena of chromosomal restitution or the existence of a rejoining system was further confirmed by Wolff (1956) and others. If restitution occurs in the first break before the formation of a second break, a chromosomal aberration of the rearrangement type is no longer possible. Therefore with decreasing dose-rates, the frequency of the two-hit aberration decreases. Thus far reports on the intensity effects of radiation on mammalian chromosomes in culture have been published. Human blood was freshly drawn and irradiated in vitro with x rays. The dose rate used was 3 R, 31 R, and 202 R per minute. The range of doses was 30 R to 240 R. Leucocytes were separated immediately after irradiation and cultured according to Moorhead with some modifications. Chromosome aberration was scored. The results of the covari-

ance analysis of data show that in both one-hit and two-hit aberrations statistically significant differences exist between the frequencies of chromosome aberrations induced by two different dose rates, 31 R/min and 202 R/min. It is concluded that the classical theory of radiation genetics is subject to some partial modification. Results indicate that intensity effects exist in one-hit as well as in two-hit chromosome aberrations. However, further investigations are required to clarify the mechanisms of intensity effects in the one-hit aberrations. Regression curves were drawn for both one-hit and two-hit chromosome aberrations on the x ray doses at different dose rate levels. Dose-square relationships were found to be significant at the high dose rate of 202 R per minute, both for two-hit and one-hit aberrations. Possible explanations were made for the non-linear dose-response of the one-hit aberrations, especially at a high dose-rate. (auth)

**1730** BREEDING VALUE OF THE RADIATION-INDUCED MACRO-MUTANT. II. EFFECT OF MUTANT EXPRESSION AND ASSOCIATED BACKGROUNDS ON SELECTION POTENTIAL IN ARACHIS HYPOGAEA L. Emery, D. A.; Gregory, W. C.; Loesch, P. J. Jr. (North Carolina Agricultural Experiment Station, Raleigh).

From Technical Meeting on the Use of Induced Mutations in Plant Breeding Programs, Rome, May-June 1964.

To determine if the background genotype of genetically stabilized macro-mutants had been permanently changed by irradiation, five distinctly different and simply inherited x ray mutants in peanuts were chosen for hybridization. Segregates of mutants with phenotype A from crosses between a mutant with phenotype A and an array of other x ray induced mutants B, C, D and E from the same autogamous line were expected to differ as a function of the segregating backgrounds of the B–E mutants in the array. It was concluded that the background of the parental macro-mutants had indeed been mutated. Statistical differences of significance for several quantitative characters were noted among and within the hybrid families displaying the same macro-mutant phenotype derived from the different mutant cross combinations. A second experiment was therefore conducted whereby the mutated backgrounds were separated from the macromutant locus by chromosomal segregation. The genetic variances and combining abilities among backgrounds were then evaluated among progenies of normal-phenotype but tracing to different macromutant crosses, in the $F_4$ and $F_5$ generations. Selection for increased yield of fruit in $F_5$ generation was found to be generally effective in those background combinations where significant variances were noted in the $F_4$. Eleven of sixteen normal appearing $F_2$ families derived from crosses among macro-mutants yielded more fruit than the highest-yielding unirradiated control family from the same autogamous line. Background mutation was not limited to the chromosome marked by the macro-mutant locus. Thus, even though the induced macro-mutant may be deleterious in its present form the diversified genetic background created via irradiation could be a valuable new source of germplasm readily stabilized in normal-appearing phenotypes. The potential value of the macromutant in a breeding program is discussed relative to: its usage as a marker, the circumvention of problems associated with genetic chimeras and the promotion of genetic and statistical analyses where the usual assumptions are held for self-pollinated crops. (TCO)

## Health Physics and Safety

*Refer also to abstracts 1312, 1317, 1328, 1379, 1455, 1487, 2094, and 2864.*

**1731** (AD-640414) EFFECTIVENESS OF SMALL EXTERNAL EPICONDYLAR LEAD CUFFS AGAINST LETHAL X-RADIATION IN DOGS. Cole, L. J.; Haire, H. M.; Alpen, E. L. (Naval Radiological Defense Lab., San Francisco, Calif.). Sept. 6, 1966. 20p. (USNRDL-TR-1068). CFSTI $1.00 cy, $0.50 mn.

Dogs were exposed to 250 kvp x radiation while wearing a small external lead shield (weighing about 600 grams) around the limb epicondyle. Such shielding permitted survival after otherwise lethal doses up to 1000 R (a dose approximately 3 times the $LD_{50}$). The protection was characterized by a critical recovery in the peripheral leucocyte counts usually observable by 12 days postirradiation. A single lead cuff was also effective against a 600 R dose of 1 Mvp x rays but not after 800 R. However, protection against mortality was evident at this radiation dose when double or triple layers of lead shield were employed. Attenuation of the radiation dose under these conditions was measured by means of lithium fluoride dosimeters appropriately placed under the lead cuff and also on a dog phantom. The theoretical basis for the findings is discussed in terms of critical functional repopulation of peripheral hemopoietic and lymphoid tissue sites via cellular seeding from the shielded marrow. It is suggested that such shielding may be practically feasible under certain military and medical circumstances. (auth)

**1732** (AD-641480) REMOVAL OF SIMULATED FALLOUT FROM ASPHALT STREETS BY FIREHOSING TECHNIQUES. Wiltshire, L. L.; Owen, W. L. (Naval Radiological Defense Lab., San Francisco, Calif.). July 29, 1965. 96p. (USNRDL-TR-1049). CFSTI $3.00 cy, $0.75 mn.

Firehosing is evaluated as a wet reclamation procedure for the operational recovery of asphalt paved streets contaminated with fallout from a land surface nuclear detonation. Preliminary tests with inert fallout simulant determined the optimum nozzle stream range and firehosing technique. Principal tests, conducted with radio-traced simulants, measured the effects of hosing rate, stream pattern, particle size, and mass loading on the fallout removal performance of firehosing. It was concluded that a slow hosing rate (visually controlled) was more effective than a faster rate, regardless of mass loading or particle size range; and the removal effectiveness improved with increased particle size range and increased mass loading; an experimental NRDL flare nozzle appeared to improve hosing performance at nozzle pressures greater than 150 psi. Graphs showing the effect of hosing rate, particle size, mass loading, and stream pattern on the reclamation performance of firehosing are presented. (auth)

**1733** (AD-641664) A COMPUTER CODE FOR ESTIMATING THE PROTECTION OFFERED BY SHIPS AGAINST FALLOUT, BASE SURGE, OR WATER POOL RADIATION. Ferguson, J. M. (Naval Radiological Defense Lab., San Francisco, Calif.). Sept. 8, 1966. 23p. (USNRDL-TR-1079). CFSTI $1.00 cy, $0.50 mn.

A method is described for estimating the shielding effectiveness of ships against various types of fallout gamma radiation fields. The method actually can be used for a wide variety of complex structures. The ship or structure is represented by a set of rectangles whose number, orientations, sizes, and thicknesses are variable. The direct radiation is calculated exactly, and the scattered radiation is approximated by buildup factors. It has been found that the calculations agree well with experiment if it is assumed that the contribution due to scattered radiation is about half that given by infinite medium buildup factors. (auth)

**1734** (AHSB(RP)-R-72) ENVIRONMENTAL MONITORING ASSOCIATED WITH DISCHARGES OF RADIOACTIVE WASTE DURING 1965 FROM U.K.A.E.A. ESTABLISHMENTS. (Authority Health and Safety Branch, United Kingdom Atomic Energy Authority, Harwell (England)). Aug. 1966. 29p. Dep.

Results are presented from environmental monitoring studies undertaken to confirm that the discharges of radioactive waste during 1965 from each of the principal UKAEA establishments produced no hazard in the environment. The results of this monitoring are summarized and are compared with derived working limits to facilitate an appreciation of the standards of safety achieved. (auth)

**1735** (CEA-R-3018) ETUDE DE LA PERMEABILITE AU TRITIUM DE DIFFERENTS MATERIAUX. (Study of the Permeability of Certain Materials to Tritium). Caire, Bernard; Sutra-Fourcade, Yves (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). Aug. 1966. 20p. (In French). Dep. mn.

Certain materials intended for use as a protection against gaseous tritium and tritiated water are classified. Active tests are discussed and an account is given of phenomena encountered with very small quantities of the element. Tests carried out using helium and inactive water are reported. Gaseous tritium was used without a carrier and, for safety reasons, it was not possible to handle it in weighable amounts. One mCi of tritium corresponds to $10^{-7}$ g of this gas. At a concentration of one $mCi/m^3$ one has therefore $10^{-7}$ $g/m^3$ of tritium. Under the same conditions, at normal pressure, a cubic meter of hydrogen weighs 900 gms. The amounts handled during the active tests are thus $10^{10}$ times less than those which would have been used in the case of hydrogen at normal pressure. (tr-auth)

**1736** (CEA-R-3019) LA RADIOPROTECTION DES INSTALLATIONS DE DEGAINAGE DES COMBUSTIBLES IRRADIES ET DES RADIOELEMENTS A MARCOULE. (The Health Physics of Installations for Uncanning Irradiated Fuels or For Handling Radio-Elements at Marcoule). Chassany, Jean; Guillermin, Pierre; Mallet, Pierre (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). Aug. 1966. 78p. Dep. mn.

Radiation protection practices for handling reactor fuel elements are described. Elements of considerable specific radioactivity are handled under water. A study was made of water filtration and of ventilation in the building. The installations are divided up into zones depending on the radioactive risks, and the radiation level atmospheric contamination are the object of a systematic

control at various points. A description is given of all aspects of health physics which have been encountered during six years: storage, transfer of radioactive material, uncanning, rolling, waste disposal, specialized operations, installations in operation and at rest, and transport. In spite of the gradual increase in the activity of these installations, the total doses received by the personnel have hardly altered and the number of cases of physical contamination has diminished. (auth)

**1737** (CLOR-48/D) DOSIMETRY OF ENVIRONMENTAL GAMMA-RADIATION IN POLAND BY MEANS OF GAMMA-RAY SPECTRA IN THE FIELD. Pensko, J. (Centralne Laboratorium Ochrony Radiologicznej, Warsaw (Poland)). 1966. 27p.

The direct measurements of the gamma-ray background exposure rate in Poland was carried out by means of ionization chambers of Geiger-Müller counters. These methods are very sensitive and accurate but they do not allow the separation of natural gamma background from the fallout components. The exposure rate caused by fallout was usually determined by the concentration measurements of the more important fission products in the soil or plants. Some experiences with the spectrometric method are presented that show it is possible to make direct evaluations of dose rates from the main gamma emitters of background radiation. Some results obtained were compared with the exposure rate computation after the estimation of potassium, uranium, and thorium concentration in the soil samples. The 1962 to 1965 results of environmental dose rate measurements of more important gamma emitters, natural and fission products, for 20 different places in Poland are presented and discussed. (auth)

**1738** (COO-1422-9) PROGRESS IN DEVELOPMENT OF A BONE-EQUIVALENT MATERIAL. Sorenson, J. A.; Witt, R. M.; Cameron, J. R. (Wisconsin Univ., Madison). July 15, 1966. Contract AT(11-1)-1422. 4p. Dep. mn. CFSTI $0.50 mn.

A bone-equivalent material was prepared for use in radiation studies. The material is a mixture of human cortical bone ash and a soft tissue-equivalent plastic that has electrical properties similar to muscle. The material is easily handled, machinable, and apparently inert. Pieces of the material were reheated and pressure molded into various sizes and shapes and tested for density, uniformity, and photon absorbing properties at energies of 27 keV ($^{125}$I) and 60 keV ($^{241}$Am). The values for mass absorption coefficients measured on the synthetic material agreed well with published values on the elemental composition of bone. (C.H.)

**1739** (GAT-528) ENVIRONMENTAL RADIATION LEVELS AND CONCENTRATIONS, FIRST HALF 1966. Kalmon, B.; Hulett, S. H. (Goodyear Atomic Corp., Piketon, Ohio). Sept. 1, 1966. Contract AT(33-2)-1. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Data are summarized from a survey of environmental radioactivity in the environs of the Portsmouth Area Gaseous Diffusion Plant during the first half of 1966. (C.H.)

**1740** (HASL-173 and App.) FALLOUT PROGRAM QUARTERLY SUMMARY REPORT, JUNE 1, 1966–SEPTEMBER 1, 1966. Hardy, Edward P. Jr.; Rivera, Joseph (Health and Safety Lab., New York Operations Office (AEC), N. Y.). Oct. 1, 1966. 472p. Dep. mn. CFSTI $7.00 cy, $2.00 mn.

This report and appendix are issued separately, but cataloged as a unit.

Data are presented from the HASL Fallout Program, Argonne National Laboratory, the Argentine Atomic Energy Commission, the Department of Scientific and Industrial Research in New Zealand, the National Radiation Laboratory in New Zealand, EURATOM Joint Nuclear Research Centre, and Isotopes, Inc. Radionuclide levels in fallout, milk, tapwater, diet, surface and high altitude air, are given in tabular form. The initial section consists of interpretive reports and data summaries covering the following topics: strontium-90 levels in soils collected from 1964–1966; fission products in rain collected at Argonne after the third Chinese test; radionuclides in surface air at Argonne in 1965 and 1966; strontium-90 in the diets and bones of children from Argentina; strontium-90, stable strontium and calcium in infant diets; predictions of strontium-90 levels in diet; and statistical tests of the equivalency of the pot and column collectors. A bibliography of 121 recent publications related to radionuclide studies is included. (auth)

**1741** (NP-16263) K VOPROSU O RASPREDELINII $^{90}$Sr V SKELETE VZROSLOGO CHELOVEKA. (The Distribution of $^{90}$Sr in the Adult Human Skeleton). Marei, A. N.; Yartsev, E. I.; Moiseenko, E. I. (Institut Atomnoi Energii, Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow). 1965. 10p. Dep. mn.

Results are presented from detailed investigations of the $^{90}$Sr content in various bones from 20 adult human skeletons examined in 1963. The distribution of $^{90}$Sr within the skeleton was found to be quite uneven, with maximum concentrations in the cranium and pelvis and average concentrations in the ribs. A comparison of the findings with data accumulated since 1957 confirmed a downward trend in $^{90}$Sr content in bones. (C.H.)

**1742** (NP-16325) DATA FROM RADIATION PROTECTION PROGRAMS. Volume 4, Number 8. (Department of National Health and Welfare, Ottawa (Ontario). Radiation Protection Div.). Aug. 1966. 26p. Dep. mn.

Data are presented on radioactivity due to fallout in Canada during July, 1966. Monthly average values for total $\beta$ activity in atmosphere and precipitation and $^{137}$Cs and $^{90}$Sr content in milk are compared with values for the previous months in 1965 and 1966. Results are also summarized from environmental monitoring for radioactivity in the environs of Canadian reactors. (C.H.)

**1743** (NYO-3109-19) STUDIES OF OCEANOGRAPHIC FACTORS AFFECTING THE USE OF NUCLEAR POWER SOURCES IN OR ADJACENT TO THE SEA. Progress Report, October 1, 1965-June 30, 1966. (Johns Hopkins Univ., Baltimore, Md. Chesapeake Bay Inst.). Contract AT(30-1)-3109. 9p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Progress is reported on studies of methods for the evaluation of potential hazards that might occur from the purposeful or accidental release of radioactive materials from an existing or proposed nuclear installation or device in the sea. Existing oceanographic knowledge was used to develop equations for use in the evaluation of a series of offshore sites along the continental slope of the Atlantic Ocean off the U. S. as possible locations for SNAP-type power sources on the ocean bottom. Emphasis was placed on studies on the effects of heated water discharged into the estuarine or coastal environment on physical processes of movement and dispersion of radioactive materials and also on excess heat. The studies led to the conclusion that a promising method for providing initial mechanical dilution of heated effluent would be the discharge of the effluent as a jet having excess momentum as compared to the receiving waters. A relatively simple theoretical relationship was developed for the dilution of the excess heat along the length of the plume as a function of the ratio of the discharge velocity to the velocity of the receiving waters and of the width of the discharge canal. Preliminary studies were made on the loss of heat at the water surface. (C.H.)

**1744** (ORNL-P-2377) MULTILABORATORY INTERCOMPARISONS OF NEUTRON DOSIMETRY SYSTEMS. Auxier, J. A. (Oak Ridge National Lab., Tenn.). [1965]. Contract W-7405-eng-26. 12p. (SM-76/12; CONF-660807-3). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna, Austria.

A multilaboratory intercomparison of neutron dosimetry systems used at 7 laboratories and production plants was made following two exposures during which the Health Physics Research Reactor (HPRR) was used in the burst made to simulate accidental nuclear excursions. On the first day the HPRR was pulsed in a low scatter geometry with the dosimeter systems set up along an arc of 3 m radius and on the second day the experiment was repeated with a 20-cm-thick graphite moderator between the reactor and the dosimeters. During the first exposure a live burro was positioned along the arc to serve as a phantom complete with a heterogeneous and circulating source of blood Na. On the second run cylindrical containers of saline solution were used for this purpose. Results of dosimetry measurements were tabulated and compared and the relative reproducibility of results was tested by a second test series approximately 6 mo later. The performance of the various dosimeter systems used for neutron and $\gamma$ dosimetry are discussed. (C.H.)

**1745** (RFP-815) ROCKY FLATS CONTINUOUS AIR MONITOR. Kirchner, R. A.; Griep, V. R.; Hartzell, W. M. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Nov. 2, 1966. Contract AT(29-1)-1106. 7p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A reliable and inexpensive (less than $400) continuous air monitor was developed. The air monitor, an alpha scintillation device, continuously monitors air samples collected on 47-mm filter paper. A readout is provided by a transistorized rate meter and an adjustable meter relay. The meter relay actuates an alarm when a preset amount of activity is collected on the filter paper. An outlet plug is provided for a recorder if one is desired. Based on a Radioactivity Concentration Guide (RCG) of 9 dpm/M$^3$, the continuous air monitor is capable of identifying as little as 1 RCG-day and alarming at this amount. At Rocky Flats the instrument is usually set to alarm at approximately 3 RCG-days above natural background radiation. Numerous instruments are located throughout plutonium-handling areas and employ a warbling alarm as an indication that respiratory protection is required. (auth)

**1746** (SZS-9/66) DIE BERUFLICHE STRAHLENBELASTUNG 1965 IN DER DEUTSCHEN DEMOKRATISCHEN REPUBLIK. (The Professional Radiation Burden in 1965 in the German Democratic Republic). Brasack, G. (Staatliche Zentrale fuer Strahlenschutz, Berlin (East Germany)). Aug. 1966. 18p. Dep. mn.

Results are reported from measurements ot the radiation dose received during 1965 by 20,133 persons residing in the German Democratic Republic who were exposed to x radiation or radiations from radioisotopes during medical examinations or during medical or industrial uses of radiation sources. Surveys were conducted monthly on those persons showing an exposure of over 0.4 rad. The data were compared statistically with data obtained in 1963 and 1964. (C.H.)

**1747** (ORNL-tr-1250) DOSE RATE AND MAXIMUM PERMISSIBLE FLUX OF HIGH ENERGY ELECTRONS AND GAMMA-RAYS. Tesch, K. (Deutsches Elektronen-Synchroton, Hamburg (West Germany)). Translated for Oak Ridge National Lab., Tenn., from report DESY-ST-1. 11p. Dep. mn. JCL $1.60 fs, $0.80 mf.

The dose rate produced by 5.2-Gev electrons and by 6.3-Gev bremsstrahlung in tissue-equivalent material was measured using a tissue-equivalent ionization chamber. From this measurement and known low-energy data the particle flux densities corresponding to a dose rate of 2.5 mrem/h are deduced for electrons, γ-rays, and bremsstrahlung with energies up to 10 Gev. (auth)

**1748** THE RADIOACTIVE CONTAMINATION OF FOODS BY FALLOUT. II. CONTAMINATION BY $^{90}Sr$ IN FOODS SAMPLED IN THE MUNICIPALITY OF BERGAMO DURING THE YEAR 1963. Molinari, G.; Crispino, L. (Centro per la Rilevazione della Contaminazione Radioattiva, Pavia, Italy). Riv. Ital. Ig., 24: 464-70 (Sept.-Dec. 1964). (In Italian).

The $^{90}Sr$ of foods collected in 1963 from retail markets in Bergamo, Italy, was assayed. Milk was collected at monthly intervals. The 12 monthly values in pC/l from Jan. 1963 to Dec. 1963 were as follows (corresponding figures for strontium units, pC $^{90}Sr$/g Ca, are in parentheses): 11.5 (11.4), 26.8 (25.9), 21.2 (19.6), 21.6 (19.6), 17.4 (17.1), 31.6 (29.5), 33.4 (38.8), 43.3 (43.9), 23.3 (19.7), 26.0 (23.9), 46.0 (40.7), and 41.4 (36.3). Results for green vegetables in Bergamo were as follows, pC/kg (pC $^{90}Sr$/gCa): lettuce 62.4 (90.4), asparagus 9.2 (44.2), zucchini (squash) 10.1 (45.4), tomato 13.3 (89.1), peppers 15.1 (270.7), cauliflower 9.3 (26.4), spinach 43.5 (75.0), and greens 6.8 (22.9). Values for fruits were: melon (1962) 3.6 (61.8), pear (1962) 5.2 (56.2), prunes 13.6 (413.6), peach 13.7 (44.4), and white grapes 13.1 (109.1). Average values for other products assayed were: cheese (1961) 14.6 (1.8), ice cream 27.5 (28.4), eggs 0.18 (--), pasta 10.7 (72.4), and wheat 1485 (3746). The per capita consumption via various food products was estimated (pC $^{90}Sr$/yr): bread 3378, pasta 730, tomato 137, eggs 28, cheese 1440, fruit 1095, green vegetables 2156, milk 2300, and total diet 11,264. (BBB)

**1749** X-RAY PELVIMETRY: A CONTEMPORARY VIEW. Tricomi, Vincent; Kohl, Schuyler G. (Downstate Medical Center, Brooklyn). Clin. Obstet. Gynecol., 9: 44-58(Mar. 1966).

The frequency, indications for, technique, and hazards of x-ray pelvimetry are considered. Approximately 250,000 x-ray pelvimetries are made yearly in the United States. The concern over fetal and maternal hazards from radiation has diminished the use of x-ray pelvimetry. According to the Genetics Committee of the National Academy of Sciences the permissible accumulated dose of medical radiation is 10 R in the first 30 years of life. It is estimated that the mother's gonadal dose from pelvimetry varies from 2 to 4 R and that of the fetus from 0.5 to 7.0 R. These doses may be reduced from one-half to three-quarters by the use of high-speed screens and films, reduction in amperage, and shielding of the patient. The amount of radiation is high enough to preclude pelvimetry as a routine practice, but not when the obstetrician believes it is necessary. An evaluation of children whose mothers prior to the conception had received high levels of radiation, showed that there was no detectable damage in their offspring. The failure to demonstrate genetic damage does not exclude the possibility of mutations in subsequent generations; however, such reports give support to the safety of the use of x-ray pelvimetry when indicated. (TCO)

**1750** SOME FACTORS FOR THE CALCULATION OF INFINITE-PLANE EXPOSURE RATES FROM GAMMA RADIATION. Crocker, G. R.; Connors, M. A.; Wong, D. T. K. (Naval Radiological Defense Lab., San Francisco). Contract AT(49-7)-1963. Health Phys., 12: 1327-32(Sept. 1966).

Some factors are presented for converting activities of fission products and some induced radioactivities to exposure rates, in R/hr, at 3 ft above an infinite, uniformly contaminated plane. (auth)

**1751** CONSULTING PRACTICE OF HEALTH PHYSICS. Blatz, Hanson (New York City Office of Radiation Control). Health Phys., 12: 1347-52(Sept. 1966).

For almost 20 years, the National Committee on Radiation Protection has recommended that radiation installations, x-ray installations in particular, be planned with the assistance of a qualified expert. It also recommends that when such a radiation installation has been placed in operation, a radiation survey be conducted by a qualified expert. Radioisotope licenses usually require the designation of a properly qualified Radiation Safety Officer. It is recognized that many small users cannot employ a full-time adequately qualified person to serve as Radiation Safety Officer. The individual owner or operator usually designates himself or a technician assistant to serve, but such a relatively unqualified person should have access to the services of a radiation protection consultant to help plan the facilities and program and to offer continuing services as needed. The difference between professional and technician health physics services is discussed and also the need for a clearer distinction to be made in practice. (auth)

**1752** $^{24}Na$ PRODUCTION IN SALINE-FILLED PHANTOMS UNDER NEUTRON IRRADIATIONS. Davy, D. R.; Peshori, L. H.; Poston, J. W. (Oak Ridge National Lab., Tenn.). Health Phys., 12: 1353-6(Sept. 1966). (ORNL-P-1779).

Results are given for sodium-24 production in sodium chloride-filled aluminum cylinders varying from 2 to 18 in. in dia exposed to a flux of $1.2 \times 10^{11}$ neutrons/cm$^2$ at a distance of 3 m from the ORNL Health Physics Research Reactor. The individual doses received in past criticality accidents were then re-determined and the correlation to the 120-day blood profile score was found. The effects of body orientation at the time of exposure was determined using a polyethylene man phantom filled with sodium chloride solution. Wall effects were tested by lining aluminum cylinders with polyethylene. (C.O.)

**1753** RADIOACTIVITY-ACCIDENT HAZARDS. Leppard, L. B. (Ontario Dept. of Health, Toronto). Can. J. Public Health, 57: 355-6(Aug. 1966).

The nature of the hazards from radioactive materials, especially $^{239}Pu$ is described briefly. Also discussed are the hazards associated with small quantities of radioactive isotopes, reactor fuel fabrication and transportation, together with safeguards required. (F.S.A.)

**1754** USE OF REDUCED-PRESSURE-PRINCIPLE BACK-FLOW PREVENTERS AT ORNL. Baird, J. N. Jr.; Cristy, G. A. Nucl. Safety, 7: 333-76(Spring 1966).

The description, testing, and installation of reduced-pressure-principle backflow preventers in the ORNL potable-water system are discussed. (H.D.R.)

**1755** PREDICTION OF $^{131}I$ IN MILK FOR PROTECTIVE-ACTION PLANNING. Stigall, G. E.; Leary, A. G. Nucl. Safety, 7: 364-70(Spring 1966).

Mathematical equations are developed for use in predictions of the atmospheric dispersion, ground deposition, and concentration in milk of $^{131}I$ that might be released to the environment. Calculations of atmospheric dispersion and ground deposition of $^{131}I$ are presented, and subsequent discussions deal with ground deposition, the concentration of $^{131}I$ in milk, and the resulting thyroid dose to a one-year-old receptor. The use of the mathematical equations presented to evaluate actual emergency surveillance techniques would point out some of the present inadequacies in predetermination of a proper response to an accident at a nuclear facility and the pitfalls of the use of ratios in predictions of estimated thyroid doses to people. (auth)

**1756** REVIEW OF HEALTH PHYSICS SOCIETY PAPERS ON ENVIRONMENTAL MONITORING, HAZARDS ANALYSIS, AND WASTE DISPOSAL. Mawson, C. A. (Atomic Energy of Canada Ltd., Chalk River, Ont.); Cowser, K. E. Nucl. Safety, 7: 370-4 (Spring 1966).

A review is presented of papers on three topics discussed at the Tenth Annual Meeting of the Health Physics Society: environmental monitoring, hazards analysis, and waste disposal. In this review, papers on radiation exposures in the vicinities of nuclear operations at Oak Ridge, Hanford, and Savannah River, which were presented in the session on environmental monitoring, are discussed. Also, problems in environmental monitoring dealing with economy, practice and theory, cloud dispersion, dietary surveys, underground explosions, tritium in Japan, and the conversion of liquid waste to solids are covered. For the session on hazards analysis, several papers on internal and external dose estimates and exposures following the release of radionuclides are summarized. With regard to waste disposal, some recent tests concerning the ultimate disposal of liquid waste by the hydraulic-fracturing tech-

nique are described briefly, and studies of liquid-waste disposal at Oak Ridge and Hanford are reviewed. A brief comment on U. S. and Soviet waste-disposal standards is also given. (auth)

**1757** RESPIRATORY PROTECTION FOR NUCLEAR RESEARCHERS. Dauw, B. J. Nat. Safety News, 93: 46-9(Mar. 1966).

Radioactive aerosols and gases constitute a serious respiratory hazard at Argonne National Laboratory. Other materials, such as insecticides and inert atmospheres, also represent respiratory hazards. The Industrial Hygiene and Safety Division provides three methods of control. The first is the application of engineering control measures including substitution of less toxic materials, containment, and ventilation. The second is the use of portable auxiliary ventilation equipment which includes mobile exhaust filter units for controlling airborne contamination where ventilation is restricted and permanent local exhaust facilities are not available. The third method is adequate respiratory protective equipment which is used only in emergencies or as backup protection in nonemergency situations. Three types of respirators are available to Argonne personnel, the half facepiece respirator, the full facepiece respirator, and supplied-air equipment. The half facepiece respirator can be equipped with three interchangeable aerosol filters to provide protection against dusts, mists, fumes, smokes, toxic particles and finely divided particulates. The full facepiece respirator is the air-purifying, full facepiece U. S. Army Assault Mask M9A1, which is the minimal respiratory protection worn in atmospheres involving a radiation hazard. The supplied-air equipment includes both air line-supplied and self-contained breathing apparatus. Lectures and demonstrations on the operation of different types of respiratory equipment are presented annually. (H.L.W.)

**1758** STUDIES ON PROTECTION AGAINST X RAYS IN UROLOGICAL PRACTICE. Komatsu, Sugao (Komatsu Hospital, Uwajima City, Japan). Hinyokika Kiyo, 11: 397-401(May 1964). (In Japanese).

The max permissible doses recommended by the International Commission for Radiological Protection are discussed in terms of exposure of patients and personnel in urologic x-ray diagnosis. It is suggested that many urologists using x rays are ignorant of optimal protective practices. Strict standards on the use of x-ray equipment are required. Measurements were made of the incident and scattered radiation doses under various conditions. Exposure to various body parts during renography is shown. Optimal operating conditions, such as filtration, collimation, and voltage, for reducing exposure to a minimum are explained. Means of detecting excessive exposure are presented. A survey is described which was made of 85 urologic clinics using x-ray equipment to evaluate the extent of radioprotective practices in Japan. (BBB)

**1759** CONTRIBUTION TO THE STUDY OF ULTRASONIC RADIODECONTAMINATION OF SKIN AFTER EXTERNAL CONTAMINATION BY RADIOCERIUM ($^{144}$Ce). Gligorijevic, J.; Petrovic, B.; Jankovic-Zagorcic, A.; Draganovic, B.; Begovic, J. (Inst. for Application of Nuclear Energy in Agriculture, Veterinary Medicine, and Forestry, Belgrade). Acta Vet. (Belgrade), 15: 193-202(1965). (In Serbian).

The effect of ultrasonic decontamination of the skin of white rats, penetration of $^{144}$Ce into some layers of the skin, and the volume of transcutaneous resorption were investigated radiometrically and autohistoradiographically. The results indicate that practical solutions for the increase of protection efficacy and decontamination of skin of domestic animals are in the stimulation of the functional and morphological properties of skin as a means for protection against the environment. (JPRS)

**1760** URANIUM CONCENTRATION IN THE URINE OF THE PERSONNEL OF A NUCLEAR CENTER. Giubileo, M.; Camera, V. (EURATOM-CCR, Ispra, Italy). Med. Lavoro, 56: 81-90(1965). (In Italian).

The concentration of natural uranium in the urine of 78 workers from the groups of industrial chemistry and metallurgy of uranium, was followed for 3 years. A total of 1471 analyses were done with the fluorometric method. The urine checks were done every week, or every 15 days or more according to the amount of exposure, which was evaluated by investigations done at the place of work and on the basis of information collected from the workers during the periodical medical examinations. The validity of this criterion was proven by the data obtained: the majority (74%) of the analyses of personnel least exposed revealed levels equal to or inferior to 1 gamma/liter, whereas (66%) the group with an intermediate risk showed 1 to 5 gamma/liter, and in the group most exposed levels of 5-10 gamma/liter were found in 37% of the cases; from 10-20 gamma/liter in 19%; and from 20-50 gamma/liter in 7% of the cases. Only 1% of the samples had a level superior to 50 gamma/liter. The attempt to establish a correlation between the level of uranium found in the air and in the urine gave no tenable indication concerning the real work risk, due to the variability of atmospheric contamination with time and the incessant movement of almost all the workers from one laboratory to another during the day. (auth)

**1761** REPORT OF COMMITTEE V ON THE HANDLING AND DISPOSAL OF RADIOACTIVE MATERIALS IN HOSPITALS AND MEDICAL RESEARCH ESTABLISHMENTS (1964). Recommendations of the International Commission on Radiological Protection. ICRP Publication 5. Oxford, Pergamon Press, 1965. 55p. 20s.

Recommendations of the International Commission on Radiological Protection regarding the handling and disposal of radioactive materials in hospitals and medical research establishments are presented. Emphasis is placed on the design of facilities in isotope laboratories, and hospital wards, and operating rooms to provide maximum protection to personnel and patients during the use of radioactive materials; procedures for the safe disposal of radioactive waste products and contaminated materials; and procedures for the handling, storage, and transportation of radioactive materials. Topics discussed include pre-employment and periodical medical examinations of personnel engaged in radiation work, personnel monitoring, environmental monitoring, procedures for radiation protection during work with unsealed and sealed radiation sources; a classification of radioisotopes used for medical purposes according to relative radiotoxicity per unit of activity; contamination control and decontamination procedures for buildings, equipment, clothing, and personnel; the disposal of airbone radioactive liquid, and solid wastes; the transportation and storage of radioactive materials, the discharge of hospital patients during treatment with radioactive materials; and the post-mortem examination, embalming, and disposal of radioactive cadavers. (C.H.)

**1762** VORKOMMNISSE UND STRAHLENUNFAELLE IN KERNTECHNISCHEN ANLAGEN AUS 20 JAHREN INTERNATIONALER ERFAHRUNG. (Occurrences and Radiation Accidents in Nuclear Technology Installations from 20 Years International Experience). Schulz, Erich H. Munich, Verlag Karl Thiemig KG, 1966. 425p. DM 128.-.

The major radiation incidents and accidents that have been reported in the international literature since 1943 are reviewed. Where available, the cause of the incidents, the personnel injuries, and material damage are given. Occurrences and accidents in critical assemblies, nuclear reactors, and uranium chemical installations, particle accelerators, fuel element chemical plants, transportation of radioactive materials, earth and rock removal by nuclear energy, weapon tests, and in radiodiagnostics and radiotherapy are included. The safety of nuclear technology installations is illustrated by the data presented. (J.S.R.)

**1763** RADIATION PROTECTION. PRINCIPLES OF ENVIRONMENTAL MONITORING RELATED TO THE HANDLING OF RADIOACTIVE MATERIALS. ICRP PUBLICATION 7. A Report by Committee 4 of the International Commission on Radiological Protection. New York, Pergamon Press, 1965. 15p.

Recommendations, adapted in 1965, of the Task Group on Environmental Monitoring of the International Commission on Radiological Protection for environmental monitoring of radioactivity outside the boundaries of installations handling radioactive materials or radiation sources are reviewed. The broad objectives of environmental monitoring programs, as set forth by the Task Group, include the assessment of the actual or potential exposure of the public to radioactive materials or radiation present in this environment, estimations of probable upper limits for such exposure, research related to the assessment of exposures, and public relations activities. Topics discussed include the design of preoperational and operation environmental monitoring programs and the planning of emergency survey procedures. While this section deals principally with surveys in the vicinity of installations, the procedures are also applicable to surveys involving accidents during the transport of radioactive materials. (C.H.)

**1764** PROPOSED NEUTRON FLUX DENSITY STANDARDS AT THE NATIONAL PHYSICAL LABORATORY. Axton, E. J.; Robertson, J. C.; Ryves, T. B. (National Physical Lab., Teddington, Eng.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/1, 12p. (CONF-660807-7). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

Facilities are being provided at the National Physical Laboratory to establish monoenergetic neutron flux density standards

over a large part of the energy range from thermal to 19 MeV. A 3-MeV Van de Graaff positive ion accelerator is used in conjunction with a 25°-0-25° analyzing magnet to direct accelerated beams of protons, deuterons or alpha particles along one of three flight tubes. The target of the left-hand beam is situated in a low scatter environment where monoenergetic neutrons over a wide energy range are produced by suitable choice of charged particles, target material, particle energy and angle. Flux densities will be measured by associated particle detectors, proton recoil detectors, threshold and resonance detectors and a long counter. The right-hand beam will be devoted to total output measurements with a flat response detector such as the manganese bath or the boron pile. These instruments are highly suited to neutron measurement in the intermediate energy range. The center beam is devoted to a thermal neutron flux facility. The charged particle beam is oscillated rapidly between two targets situated about a meter apart in a graphite pile measuring 250 cm × 150 cm × 150 cm. A zero gradient thermal flux density of about $10^7$ n/cm$^2$ sec will be produced in a 100 cm$^3$ cavity between the two targets, and by means of a thermal column, a thermal neutron beam of about one maximum permissible level will be provided. Much of the installation work was carried out and measurements are expected to commence shortly. (auth)

**1765** EXPERIMENTAL STUDY OF THE RELATION BETWEEN DOSE ABSORBED IN THE BODY AND DOSE MEASURED WITH TISSUE-EQUIVALENT COUNTERS IN THE CASE OF FAST NEUTRON IRRADIATION. Tardy-Joubert, Ph.; Pages, L. (CEN, Saclay, France). (In French). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/29, 12p. (CONF-660807-31). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

In the case of irradiation by a point source or a beam of fast neutrons, the absorbed dose rate found at the surface of a tissue-equivalent phantom is greater than the value obtained when the measuring instrument is in air. The calculated ratio is between 1.3 and 1.5 for 0.5 to 10 MeV neutrons. Experimental results obtained using a proportional counter with tissue-equivalent walls are presented and results are compared with calculated values. The transmission in the case of irradiation in an isotropic flux was studied, and experimental data for various sources are presented which show that the maximum dose in the body under these conditions is considerably less than the dose measured with a thin-wall counter (or first collision dose). The same investigation was carried out systematically in the experimental zones around the accelerators in the Saclay Nuclear Research Center. All the data show that in evaluating the hazards to personnel, the dose measured with a thin-wall counter (300 mg cm$^{-2}$) must not be multiplied by a factor between 1.3 and 1.5, but by a figure which is always less than unity. (auth)

**1766** DOSE EQUIVALENT OF γ-NEUTRON RADIATION. Keirim-Markus, I. B.; Kochetkov, O. A.; Popov, V. I. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/46, 10p. (In Russian). (CONF-660807-20). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

Report 10a of the International Commission on Radiological Units and Measurements (ICRU) published in 1962 concerning γ-neutron dosimetry is discussed. The authors consider the ICRU's definitions of dose equivalent and quality factor too imprecise and propose that these concepts be defined with greater precision. The importance of using the dose equivalent in personnel monitoring and the need to develop methods of measuring it in rem are discussed. Possible ways of devising a rem-meter are considered. (C.H.)

**1767** ACCELERATOR STRAY NEUTRON DOSIMETRY: SPECTRA OF LOW AND INTERMEDIATE ENERGY NEUTRONS. McLaughlin, J. E.; O'Brien, K. (Atomic Energy Commission, New York). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/14, 24p. (CONF-660807-24). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The control of stray radiations from the shields of large accelerators depends on good dosimetry, and in turn on an understanding of the energy spectra and fluxes. For this reason, and because neutrons are generally considered the particle of greatest biological interest, the Health and Safety Laboratory has investigated stray neutron spectrometry for several years. The important requirement that the measurement devices be transportable, and the difficulties often encountered in the use of counters and similar detectors at accelerators, led first to the use of nuclear emulsions for the region between 0.5 and about 20 MeV. Supplementary neutron flux measurements were obtained with cobalt-paraffin neutron flux integrators. The emulsion processing and scanning techniques, and the iterative unfolding computations, have been discussed elsewhere. To extend the spectrometric range over 20 and below 0.5 MeV, variations of the multi-sphere Bonner spectrometer were used. For these systems, calculated response functions were incorporated into the unfolding computations, because these functions contain no interpolated maxima, as do those developed originally from measurements. Within the past year, measurements were obtained at selected locations near a number of accelerators in the United States. Measurements with the two spectrometers are compared to evaluate the effect of the different energy ranges and resolutions. To expand further the measurable neutron energy range, two higher energy spectrometers are in development. One is a Bonner spectrometer, with an 18-inch diameter polyethylene sphere, to improve the resolution at high energies, near 100 MeV. The other is a neutron spectrometer using a small proton spark chamber designed for the 10 to 200 MeV region. From information on energy spectra and flux, estimates can be obtained of the important derivative quantities of average absorbed dose or dose equivalent. It was inferred from the spectral results the specific dose in rads/(n/cm$^2$). The present results permit direct comparisons among various accelerators and indicate they are an aid in examining shield adequacy and selecting survey instruments. The two higher energy spectrometers, together with the emulsion and standard Bonner spectrometer, will permit more extensive investigations of stray neutron spectra from thermal energies to about 200 MeV. (auth)

**1768** POSITRON RADIOISOTOPE CAMERA. Aronow, S.; Burnham, C. (Massachusetts General Hospital, Boston). 3p. (CONF-650843-1). ORAU.

From 6th International Conference on Medical Electronics and Biological Engineering, Tokyo.

Gamma-emitting radioisotopes have proven valuable in medical practice in the visualization of organs or abnormal regions of organs. At present the most commonly used instruments are mechanical scanners. In these, a detector, suitably collimated to view a small portion of the source, moves over the surface to be examined. These scanners are, in general, slow and insensitive. An obvious improvement would be a stationary, camera type of detector that views the entire source continuously and that determines spatial distribution by electronic rather than mechanical displacement. The camera developed by Anger has proven quite successful. This uses a thin NaI(Tl) crystal as the basic detector. An array of photomultiplier tubes views the light output due to each absorbed γ-ray. A camera is described that uses a thin NaI(Tl) crystal as the basic γ ray detector, but views the light burst with an imaging system consisting of a series of image intensifier tubes and a television camera. The camera is similar to the standard intensifier-TV chain used for conventional radiological fluoroscopy. The inability to use x-ray techniques for γ-ray visualization is due to the much higher energy per photon of the γ-rays and the much smaller number of available photons. (H.G.D.)

**1769** EXPERIMENTAL APPRAISAL OF THE VALIDITY OF NEUTRON DOSIMETRY THEORY IN RADIATION PROTECTION. Watt, D. E.; Lawson, R. C.; Clare, D. M. (United Kingdom Atomic Energy Authority, Chapelcross, Scotland). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/35, 16p. (CONF-660807-35). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

A detector made from a thin layer of plastic scintillator arranged to conform with the Bragg-Gray principle was used to determine accurate values of kerma for tissue at a point in air and also multicollision dose, quality factors, dose equivalent, and LET spectra at depth in tissue for Be–Pu, D–D, and D–T neutrons incident on tissue-like materials. Experimental results are presented and compared with theory. An empirical relationship between thermal neutron distribution at depth in tissue for incident fast neutron beams was determined in terms of beam size and fast neutron relaxation length in tissue. (auth)

**1770** CRITICAL REVIEW OF RADIATION REGULATION PRINCIPLES. Blatz, Hanson (New York Univ., New York). 6p. (CONF-660621-22). ORAU. Gmelin, AED-CONF-66-193-24.

From Health Physics Society, 11th Annual Meeting, Houston, Tex.

When most radiation regulations were originally formulated, there had been little experience in the active control of radiation hazards, except in the atomic energy program. The resulting regulations, although probably the best that could be drafted under the

circumstances, are not always appropriate, being based upon expert conjecture rather than appropriate experience. Now is the time for a critical review after years of experience gained since regulation was started. Basic changes should be made where necessary, rather than allowing dubious principles to continue as time honored traditions. A number of typical examples are given. (auth)

## Medicine

**1771** (CONF-650560-19) CHEMICAL PROTECTION AGAINST INVOLUTION OF THE CHICK THYMUS AND BURSA OF FABRICIUS FOLLOWING EXPOSURE TO X-RAYS, THERMAL NEUTRONS, OR FISSION NEUTRONS. Montour, James L. (Oak Ridge National Lab., Tenn.). [1958]. Contract W-7405-eng-26. 12p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 13th Annual Meeting of the Radiation Research Society, Philadelphia.

Two major lympho-epithelial organs found in the chicken, the thymus and the bursa of Fabricius, are radiosensitive and their weight loss measured 5 days post-irradiation is proportioned to the radiation dose regardless of the type of radiation employed, although a measurable difference is seen between the dose response of the two organs. Results are reported from studies on the protective effects of prior injection of AET on the weight loss of the thymus and bursa of Fabricius in 22-day-old cockerels exposed to sub-lethal doses of x radiation, thermal neutrons, or fission neutrons. Both the thymus and bursa of the AET-injected chicks were larger than those from similarly irradiated-non-injected chicks when examined 2 or 5 days post-irradiation. (C.H.)

**1772** (ORO-2401-8) UTILIZATION OF A LOW LEVEL WHOLE BODY COUNTING FACILITY IN THE MEASUREMENT OF ELECTROLYTE COMPOSITION AND METABOLISM IN MAN. Progress Report, 1966. Heyssel, R. M.; Brill, A. B.; Denman, E. D. (Vanderbilt Univ., Nashville, Tenn.). Oct. 28, 1966. Contract AT(40-1)-2401. 70p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The design and calibration of a whole-body scanner and applications of computer methods in analysis of $\gamma$ spectra data are described. Applications of the whole-body counter reported include measurements of the whole-body retention of $^{132}Cs$ in man following ingestion of approximately 2 $\mu$c; the simultaneous measurements of body water (using tritiated water), extracellular space (using $^{82}Br$); body sodium (using $^{24}Na$ or $^{22}Na$), and body potassium (using $^{42}K$) in patients by computer analysis of the $\gamma$ spectra obtained from the whole-body, plasma, and excretion products; and the determination of blood volume and extracellular fluid volumes in the steady state, non-steady state, and in shocked dogs using $^{35}S$, $^{131}I$-serum albumin, and $^{51}Cr$ as tracers. The levels of circulating renin and angiotensin were determined by an indirect method that consists of scintillation measurement of the clearance of subcutaneously injected $^{125}I$ Na at separate forearm sites when administered with and without angiotensin as compared with the control side, and the subsequent measurement of plasma renin activity. Progress is reported in the evaluation of an instrument designed for measuring bone mineral in vivo. The instrument consists of a collimated $^{125}I$ source of x rays, a holder for the patient's finger, a collimated scintillation detector, and a drive mechanism to permit scanning across the bone. A scintillation detector system consisting of three 2 × 2 × 1 inch NaI crystal and photomultiplier assemblies arranged in an adjustable arc to fit the neck was designed for use in counting low levels of thyroidal $^{131}I$. Applications in studies of the effect of lead poisoning on thyroid function in man showed that chronic lead intoxication causes a decrease in thyroidal $^{131}I$ uptake. The injection of $^{55}Fe$ and $^{59}Fe$ in the same individual on the same day gave additional evidence of a circadian rhythm in plasma iron turnover. A method was developed for the simultaneous liquid scintillation counting of $^{55}Fe$ and $^{59}Fe$ in biological samples. Progress is reported in the development of tracer methods using $^{55}Fe$, $^{59}Fe$, $^{51}Cr$-labeled red blood cells, and $^{32}P$ for the diagnosis of iron deficiency and iron deficiency anemia, measurements on the effects of androgens on erythropoiesis, and ferro-kinetic studies on humans. Progress is reported in the radiological dosimetry of $^{75}Se$ and studies on the effects of age on the distribution of $^{75}Se$-methionine in rat tissues. The design and calibration of a lithium-drifted germanium semiconductor detector for use in the analysis of $\gamma$ spectra are described. (C.H.)

**1773** (SZS-5/66) BIOLOGISCH-CHEMISCHER STRAHLENSCHUTZ II. ZUSAMMENFASSENDER BERICHT. (Biological-Chemical Radiation Protection II. Summary Report). Huber, R. (Staatliche Zentrale fuer Strahlenschutz, Berlin (East Germany)). May 1966. 28p. Dep. mn.

A bibliographic review is presented of data on the effectiveness of various radioprotective substances. The radioprotective agents considered are SH compounds and derivatives, amines, amino acids, vitamins, hormones, and some unclassified compounds. (88 references.) (J.S.R.)

**1774** (TID-23349) BIOLOGICAL EFFECTS OF BLAST AND SHOCK. Technical Progress Report. Richmond, Donald R.; White, Clayton S. (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.). Apr. 1966. Contract AT (29-1)-1242. 61p. (DASA-1777; AD-638342). CFSTI $3.00 cy, $0.75 mn.

Blast and shock are among the immediate effects from a nuclear explosion since they occur within a few minutes after the detonation. The scope of blast and shock biology was set forth as covering effects resulting from overpressure (primary), flying debris (secondary), and displacement (tertiary). Procedures employed in the laboratory for simulating the blast wave forms as they varied within structures on nuclear tests were described. For each effect, a selected summary of current information relating the physical parameters to given levels of biological response is presented. From this, the blast and shock hazards estimated for personnel, as a function of range and yield, are illustrated in the form of curves. The range-yield-effects relationship for the biological criteria is discussed in terms of free-field and other exposure situations. They are compared with similar range-effects data for thermal and nuclear radiation. (38 references). (C.H.)

**1775** (AD-633268) DRUGS FOR RADIATION PROTECTION. Tiunov, L. A.; Vasil'ev, G. A.; Val'dshtein, E. A. Translation of Protivoluchevye Sredstva, 1964 Spravochnik, Izdatel'stvo Nauka, Moscow-Leningrad, 1964. 596p. (FTD-TT-65-556). CFSTI $8.96 cy, $2.50 mn.

An abstract was prepared on the original report and appeared in NSA Vol. 19 as number 30,005. (829 references.) (C.H.)

**1776** CONCERNING THE REACTIONS OF THE HEMOPOIETIC SYSTEM TO DIFFERENT STIMULI IN CHRONIC AND SUBACUTE RADIATION SICKNESS. Shatalova, I. N. (Vishnevskii Inst. of Surgery, Moscow). Eksp. Khir. Anesteziol., 10: No. 5, 40-3(Sept.-Oct. 1965). (In Russian).

Dogs weighing 15-24 kilograms were used in experiments carried out to determine the morphological and functional modifications which take place in the peripheral blood and bone marrow of the organism in the development of chronic and subacute radiation sickness before and after the infliction of burns. Chronic and subacute forms of radiation sickness were induced by daily exposure of the animals to small doses of radiation. The animals were given adrenalin and pilocarpine subcutaneously. The animals were under constant clinical observation. Systematic examinations of the peripheral blood and bone marrow were conducted; blood proteins were studied; the albumin-globulin index, blood globulin fractions, and the nitrogen residue were determined. Phagocyte reactions to adrenalin and pilocarpine were observed. It was found that the continuous exposure of the dogs to x rays up to total doses of 756-850 R was accompanied by a decrease in the number of leukocytes in the blood and a decline in phagocyte activity. With the further exposure of the animals to radiation and the development of chronic and subacute radiation sickness, reactions to adrenalin and pilocarpine decreased, were perverted, or completely disappeared. Phagocyte activity was reduced to a minimum. On this background burns with a benzene flame were inflicted on the animals. Four of the six animals burned died as a result of aggravation of radiation sickness, or other complications. In others with severe forms of the combined trauma disproteinemia developed, and the bone marrow was adversely affected. (auth)

**1777** THE EFFECTS OF AMINASINE, PROMEDOL, AND DIMEDROL UPON THE DURATION OF BARBAMYL-INDUCED SLEEP IN HEALTHY ANIMALS AND UNDER CONDITIONS OF EXPERIMENTALLY PROVOKED RADIATION SICKNESS. Saidakovskii, Yu. Ya. Farmakol. Toksikol., 27: 77-81(Jan.-Feb. 1964). (In Russian).

In experiments conducted on 267 albino rats the effects produced by aminasine, promedol, and benadryl on the duration of barbamyl-induced sleep in healthy and irradiated animals were studied. It was shown that a lytic mixture tends to markedly prolong the hypnotic action of barbamyl, mainly at the expense of aminasine. In conditions of an experimentally induced radiation sickness the sensitivity to barbamyl became less intensive, especially in the period of the most pronounced manifestations of this disease. In one or five days after irradiation the prolonging action of aminasine with regard to the barbamyl-induced sleep was rather weak, but then, as the animals recovered, it became restored to its initial level. (auth)

**1778** ULCERATED THOROTRASTOMA. Girbes, J.; Palou, J.; Lopez, M. Rodriguez. An. Med. Sec. Med., 50: 147-9(July 1964). (In Spanish).

Thorotrastoma results when this contrast medium extravasates during the course of its use in angiography. Such a case is described, in which a 60-yr-old woman with varicose veins had undergone preoperative phlebography. She was found to have painful, nodular lesions in the left popliteal region. Later these lesions became ulcerated. Radiography of the knee revealed opaque material, presumably extravasated deposits of Thorotrast. Treatment consisted of extensive extirpation of the tumor mass, followed by plastic surgery. Histologic examination of the specimen showed an intense inflammatory reaction, with infiltration of lymphocytes and plasma cells, and phagocytes ingesting the particles of $ThO_2$. A necrotic zone contained deposits of $ThO_2$ being phagocytized by macrophages. No malignant changes in epithelial or connective tissue could be observed. This case illustrates how Thorotrastomas can be diagnosed radiographically and the diagnosis confirmed on the biopsy. (BBB)

**1779** COMPARATIVE STUDY OF THE EFFECT OF POLYGLUCINE OF DIFFERENT MOLECULAR WEIGHTS ON THE COURSE OF RADIATION SICKNESS IN DOGS. Shitikova, M. G.; Polushina, T. V.; Kozinets, G. I.; Lagutina, N. Ya.; Ilyukhin, A. V.; Raushenbakh, M. O. (Lenin Inst. of Hematology and Blood Transfusion, Moscow). Probl. Gematol. Pereliv. Krovi, 10: No. 10, 24-7(Oct. 1965). (In Russian).

Data on the effect of polyglucine (Dextran) with molecular weights of 15,000–20,000, 32,000–50,000, 84,000, 100,000, and 300,000 on hemopoiesis and blood coagulation in the course of acute radiation sickness are presented. Nonbred dogs 12 to 28 kilograms in weight were used in the experiments. Acute radiation sickness was induced in the animals by exposure to radiation in doses of 400 R ($LD_{80}$) and 600 R ($LD_{95}$). Polyglucine was administered either by the drop or stream method in doses of five milliliters per kilogram body weight on the day of irradiation, and then on the 1st, 2d, 5th, 7th, 11th, and 13th days after the irradiation. The animals received also penicillin, and were fed an intensified lactic-protein diet. A control group of dogs was irradiated but received no polyglucine. Eight series of experiments in which polyglucine of different molecular weights were administered to the dogs were carried out. It was established that animals which were administered polyglucine of 15,000–20,000, 32,000–50,000, 100,000, and 300,000 molecular weights developed symptoms of acute radiation sickness: the animals became sluggish, refused food, their body temperature increased, and gastrointestinal disorders accompanied by bloody diarrhea developed. The picture was different with the dogs which received polyglucine with a molecular weight of 84,000: radiation sickness was of a milder form, the animals were active, did not refuse food, and gastrointestinal disorders were of brief duration. Blood coagulation time in these animals remained at the normal level, and hemopoiesis was not affected. (JPRS)

**1780** RADIOACTIVE IODINE SODIUM IODOHIPPURATE RENOGRAM IN PREGNANCY. Rudolph, Jerome H.; Bruneau, Robert J.; Wax, Sandor H. (Univ. of Rochester, N. Y.). Surg. Forum, 16: 402-4(1965).

The radioactive renogram was assessed as a clinical tool in evaluating renal function changes in 50 pregnant women at various time intervals during pregnancy and the puerperium. Abnormal renal conditions during gestation were also evaluated. The safety of this procedure was studied in 14 pregnant patients at term. Seven patients received no thyroid-blocking medication. The fetal thyroid glands at delivery in three of these infants showed a small but insignificant concentration of radioactivity over the thyroid gland. The 7 other patients received premedication with Lugol's solution one hr prior to testing and in none of these infants was radioactive pickup demonstrated. These results indicate that a renogram during pregnancy may be normal, but more frequently shows an increased peak height probably related to increased renal plasma flow; and a slight to moderate delay of drainage which is more pronounced on the right. Within 24 to 48 hr post partum, repeat renograms reverted back to the normal nonpregnancy curves in spite of the typical dilatation seen when compared with intravenous pyelograms. This suggests that a partial pressure obstruction is rapidly relieved by parturition. In pathologic conditions associated with pregnancy, the renogram was particularly helpful in the diagnosis of obstructive calculi and in severe pre-eclampsia and eclampsia where renal function was impaired. (BBB)

**1781** BIOLOGICAL PROTECTION MECHANISMS OF RADIOPROTECTORS ON MAMMALIAN CELLS. V. CYTOLOGICAL EFFECTS OF AET ON TUMOR CELLS, BONE MARROW, AND THYMUS CELLS. Kobayashi, Jindo; Katayama, Eitaro; Kitajima, Tamio; Kawamura, Fumio (Tokushima Univ., Japan). Tokushima J. Exp. Med., 12: 40-4(May 1965).

Experiments are reported on the ability of aminoethylisothiuronium bromide hydrobromide (AET) to counteract the growth-inhibiting effect of x irradiation on tumor growth and cell division of normal tissue. Also, its ability to accelerate cell multiplication was studied by cytological methods. The mitotic frequency of MTK sarcoma III rat ascites tumor cells was examined in samples taken at 3-hr intervals after doses of 20 or 40 mg/100 g AET. The mitotic rate of the treated tumor cells became relatively high in the one to 12 hr samples. One to 6 hours after AET administration, prophase cells were increased with a slight decrease of metaphase cells at 1 hr. The mitotic rate of bone marrow cells after the AET treatment showed a similar increase to that of the MTK sarcoma III tumor cells. Prophase cells were mostly increased at one hr after AET administration and then prophase cells were gradually decreased at 3 to 4 hr. Metaphase cells were decreased one hr after the treatment and then increased 5 to 6 hours after AET administration. The recovery of mitotic cells occurred gradually 12 to 24 hours after the treatment with no overshoot above or below normal mitotic cells numbers. The effect of AET on mitoses of thymus cells of mice treated at 5 mg/24 g of body weight was also examined. A temporary overshoot above normal mitotic rate occurred at one hr in AET-treated animals and this overshoot in mitoses returned to the normal value in 12 to 24 hr. In the samples taken from 1 to 6 hr after the treatment, the relative frequency of prophase cells was increased over the normal value, while a decrease of metaphase cells occurred at one hour after AET administration. Metaphase cells increased at 6 hr after the treatment, with a decrease of prophase cells. The results suggest that one of the biological protection mechanisms associated with this radioprotector is an increase of mitotic activity of normal and malignant cells. (BBB)

**1782** EFFECT OF LASER ON BRAIN AND NEOPLASM. Rosomoff, Hubert L.; Carroll, Fred (Univ. of Pittsburgh). Surg. Forum, 16: 431-3(1965).

The ruby laser utilized in these experiments yielded a nominal output of 8 J from a max energy input of 800 J at 2 kv. The optical system was capable of concentrating the beam to a 0.66 $mm^2$ area at a distance of 9 cm. The estimated final output at the focused target was 7500 J or a power density of 5 $kw/mm^2$. The effect of laser radiation on normal animal brain and on human neoplasia under clinical conditions was studied. When the laser was applied to the heads of rats, lesions could not be created in the scalp, skull, or subjacent brain with pulses aimed at a shaved, bare, or carbon-coated head. Lesions were not found in brains lased through intact skull. The dura mater was opened in dogs and the brain was subjected to laser in multiple sites under various conditions. Lesions were created easily at the focal point, or at the surface when the beam was focused subcortically. No lesions were seen if unfocused laser was used or the beam was focused short of the surface. When the effect of intravenous or topical dye was studied, the largest lesions were found after laser exposure to brain coated with carbon. Animals given intravenous Evans blue, 2 mg/kg, had the next largest size injury. Five patients with hopeless malignancies were used for laser experimentation. Two with metastatic carcinoma in open skin lesions were lased through the depth of the tumor with repetitive, focused bursts. Columns of nonhemorrhagic necrosis were produced through the tumors, and no inflammatory response to the necrosis was seen. Laser as a potential therapeutic agent may have limited value, since bursts must be delivered sufficiently close as to overlap. However, it appears to be well tolerated, is painless, and extraordinarily large doses may be given in a short time without adverse effect systemically. (BBB)

**1783** BIOLOGICAL PROTECTION MECHANISMS OF RADIOPROTECTORS ON MAMMALIAN CELLS. IV. CYTOLOGICAL EFFECTS OF MEA ON BONE MARROW CELLS AND THYMUS CELLS. Kobayashi, Jindo; Kitajima, Tamio; Katayama, Eitaro; Kwamura, Fumio (Tokushima Univ., Japan). Tokushima J. Exp. Med., 12: 35-9(May 1965).

Previous findings suggest that the biological protection mechanism with MEA might be concerned with the mitotic activity of normal or malignant cells. To further examine this problem, mitotic activity in bone marrow and thymus cells of mice was studied. Twenty-four normal Swiss albino mice were given a 5 mg/25 g (body weight) dose of MEA, and were killed 1, 2, 3, 6, 9, 12, and 24 hr after injection and the mitotic rate of the bone marrow and thymus cells was examined. The mitotic rate of the MEA-treated bone marrow and thymus cells became relatively high from one to 9 hr. In bone marrow samples taken from one to 6 hr after MEA administration, the relative frequency of ana- and telophase cells decreased in number, with an increase of prophase cells at one hr and an increase of metaphase cells at 6 hr after the treatment. Mouse thymus cells showed the prophase cells markedly increased in numbers at one hr after MEA administration and metaphase cells markedly increased at 6 hr after treatment. (TCO)

**1784** EFFECT OF NIVOLIN PREVENTIVE ADMINISTRATION ON RADIATION CHANGES IN THE PERIPHERAL BLOOD OF RATS. Vaskov, L. (Inst. for Scientific Research in Radiology and Radiation Hygiene, Sofia). Eksp. Med. Morfol., 4: 141-2(1965). (In Bulgarian).

Studies in rats showed that 5 mg/kg of nivolin (galanthamine analog, cholinesterase-inhibiting substance) given 15 minutes before irradiation affords some protection against acute radiation disease. (JPRS)

**1785** BIOLOGICAL PROTECTION MECHANISMS OF RADIOPROTECTORS ON MAMMALIAN CELLS. III. REDUCTION EFFECTS OF THE AFTER TREATMENT BY MEA ON THE RADIATION-INDUCED CHROMOSOME DAMAGE IN TUMOR CELLS. Kobayashi, Jindo; Kawamura, Fumio (Tokushima Univ., Japan). Tokushima J. Exp. Med., 12: 24-34(May 1965).

Chromosomal aberrations were studied in MTK sarcoma III rat ascites tumor cells. On the 4th day after transfer of the ascites tumor, the tumor-bearing rat received intraperitoneal injections of 2-mercaptoethylamine (MEA) and/or x irradiation (500 R). Chromosomal aberrations were observed from 12 to 24 hr after the treatments. In samples examined 12 hr after irradiation, 32.2% of metaphasic cells had breaks or translocation of chromosomes. At 15, 18, and 24 hr after exposure, the cells with abnormal chromosomes showed 46.3, 66.7, and 53.3%, respectively. MEA increased markedly the mitotic frequency of the tumor cells for several hours after its administration, but did not induce abnormal metaphasic cells with chromosome aberrations. To study the combined effects of MEA and irradiation of the chromosomes, tumor-bearing rats received a dose of 500 R 15 min after the intraperitoneal administration of 20 mg MEA/100 g body weight. In the samples taken 12 hr after treatment, 13.5% of metaphasic cells had abnormal chromosomes, such as breaks and translocations. At 15, 18, and 24 hr after treatment, the cells with abnormal chromosomes showed 12.1, 33.3, and 26.7%, respectively. In the study of combined effects of MEA after irradiation, the tumor-bearing animals received a single intraperitoneal injection of 20 mg MEA/100 g 5 hr after 500-R irradiation. In the samples taken 12 hr after irradiation, 10.4% of metaphasic cells had abnormal chromosomes. At 15, 18, and 24 hr after irradiation, the frequencies of the cells with abnormal chromosomes were 7.0, 21.9, and 22.6%. Combined administration of MEA before and after irradiation decreased frequencies of the cells with radiation-induced abnormal chromosomes. (BBB)

**1786** SOME ASPECTS OF NUCLEAR MEDICINE. Verbeeten, B. G. J. M. (Radiotherapeutisch Instituut, Tilburg, Netherlands). Ons Ziekenhuis, 24: 192-3(May 1963). (In Dutch).

Problems encountered in establishing and staffing a large radioisotope laboratory for clinical and medical research purposes are discussed. Problems of contamination, waste disposal, and ventilation are dealt with particularly. The difficulties of finding adequately trained personnel and the heavy capital expenditure for building and equipment are emphasized. Reasons are advanced for centralized medical radioisotope laboratories as opposed to smaller laboratories in each medical installation. Close supervision for safety purposes are required and can best be handled by an experienced safety expert. It is proposed that a large radioisotope laboratory or institute be provided for each one to two million of the population, and that this institute be separate from a hospital. In spite of this physical separation, close cooperation between nuclear specialists and attending physicians could be established. (BBB)

**1787** DIAGNOSIS OF BRAIN LESION TYPES BY GAMMA ENCEPHALOGRAPHY. Kvicala, V.; Henner, K.; Dienstbier, Z. (Charles Univ., Prague). Cesk. Neurol., 29: 119-23(Mar. 1966). (In Czech).

Gamma encephalography was performed after administration of $^{131}I$ serum albumin and using scintillating collimator sound for the measurements in 450 cases with brain lesions. It was possible to recognize the type of lesion and the type of tumor. Factors important for diagnosis are discussed. (JPRS)

**1788** CYSTEINE INCORPORATION AND RADIOPROTECTION IN SACCHAROMYCES. Schaedel, U.; Lochmann, E.-R.; Laskowski, W. (Freie Univ., Berlin). Nature, 211: 431-2 (July 23, 1966).

The time dependence of cysteine incorporation and the increase of radioprotection in cells of a diploid Saccharomyces strain was studied in vitro and in vivo. Cells were exposed for different periods to a solution of 0.01M cysteine in buffer at room temperature and then x-irradiated. An optimal radioprotective effect was achieved in both s-cells and 1-cells after 10 min exposure to cysteine. The experiments show that optimal radioprotection is achieved only when a certain amount of the cysteine has been incorporated into the cell. (H.G.D.)

**1789** X-RAY DAMAGE TO THE SKIN OF THE HANDS IN PHYSICIANS. Peskova, H. (Charles Univ., Prague). Acta Chir. Plast., 2: 125-32(1960).

Radioinduced skin injury and its repair by plastic surgery are described and illustrated with reference to 46 patients, 5 x-ray assistants and 41 physicians. This skin damage was regarded as serious in 19 cases (41%) because clear histological evidence of malignant changes was found at the site of damage. In 12 cases (26%) the histological findings were assessed as precancerous, and only in 15 cases (33%) were no signs of malignancy found histologically. Five of the patients operated on for extensive and neglected changes on their hands died from carcinomatous metastases in the lymph glands and lungs. Daily and protracted scrubbing of hands with a brush and disinfectants and long hours' use of rubber gloves made the condition of the irradiated skin worse. Chronic skin changes usually occurred without any signs of acute dermatitis. These changes were observed with a latency of two yr at the earliest, most frequently of 5-8 yr, and rarely of 10-20 yr. The first objective signs of damage were usually found in the nails. The skin then became glossy, dry, and rough. The skin changes were predominantly found on the dorsum of the hands and fingers, particularly on the last two phalanges (caused during fluoroscopy). The principle of surgical treatment is removal of the damaged tissue and its replacement by healthy tissue. In small and confined foci, excision of the focus with primary suture is better than coagulation. Such plastic surgical technics are described in detail. (TCO)

**1790** HYBAROXIC RADIOTHERAPY. Del Regato, Juan A. (Penrose Cancer Hospital, Colorado Springs, Colo.). Postgrad. Med., 39: A87-9(June 1966).

Enhancement of tumor cell radiosensitivity by oxygen is reviewed from a radiobiological standpoint, and advances in use of this phenomenon in clinical practice are recounted. Apparently, oxygen under pressure restores to normal radiosensitivity anoxic areas of tumor which may have become nonsensitive to radiations. However, hybaroxia appears to stimulate the rapid development of existing metastatic tumors not in the area of irradiation. Hybaroxic radiotherapy does not render radiosensitive hitherto radioresistant malignant tumors, simplify the radiotherapeutic approach, or eliminate the need for skill in administering it. Whether or not this new approach offers otherwise unattainable results remains to be determined. (TCO)

**1791** COMPARISON OF THE RESULTS OF A TEST OF THE PROPHYLACTIC ACTION OF ANTIPHEINE, CYSTAMINE, AND THEIR COMBINATIONS. Stashkov, A. M. Ezhegodnik, Inst. Eksperim. Med. Akad. Med. Nauk SSSR, 7-8: 251-3(1963). (In Russian).

Mice received a lethal dose (700 R) of x rays. Antipheine was administered internally in doses of 50 to 400 mg/kg 15 min to 3 hrs before x irradiation and during the 1st 4 days after x raying. It decreased mortality by 35 to 47%. Cystamine, 400 mg/kg administered 30 min before x irradiation, reduced mortality by 42%. A combination of 300 mg of cystamine/kg 30 min before and 100 mg of antipheine/kg before or immediately after x irradiation reduced mortality by 50 to 54%; however, the increase in survival in comparison with the maximum effect from either of the compounds was statistically unreliable. (C.H.)

**1792** EXPERIMENTAL RESEARCH ON THE PROTECTIVE ACTION OF A QUINOLINE PREPARATION AGAINST THE HARMFUL EFFECTS OF ULTRAVIOLET RAYS ON OCULAR TISSUES. Ciurlo, G.; Altieri, G. G. (Univ., Genoa). Ann. Ottalmol. Clin. Oculist., 91: 394-400(June 1965). (In Italian).

Experiments were conducted in adult rabbits on the radioprotective action of Ascotodin, an aqueous solution which has the following composition (per 100 ml): 0.3 g N-methylbenzoquinoline methyl sulfate, 0.1 g N, N-dimethyl-N'-(p-methoxybenzyl)-N'-(2-pyrimidyl)-ethylenediamine hydrochloride, and carboxymethyl cellulose. A sunlamp providing uv radiation at a wavelength of 280 mμ was used to give an intensity 150,000 erg-sec/cm$^2$. Exposures of 1 to 14 min were used. Three groups of rabbits were used: (1) irradiated controls, (2) rabbits in which Ascotodin was instilled into the eyes 5 min before irradiation, and (3) others in which instillations were made at longer intervals before irradiation. Rabbits of the first group showed ocular manifestations 15 to 20 hr after exposure, the severity of the lesions being proportional to time of exposure. Milder corneal injury was noted in the second group treated with the preparation, and in the third group protection could be noted as late as 2 hr after its instillation into the eye. With Ascotodin protection, 10-min uv exposure gave similar corneal changes as seen after 4.5-min exposure of unprotected eyes. (BBB)

# Radiation Effects on Animals

**1793** (A-AC-82/R.211 and Add. 1 and 2) EFFECT OF IONIZING RADIATION ON THE CENTRAL NERVOUS SYSTEM. (United Nations Scientific Committee on the Effects of Atomic Radiation). May 1966. 96p.

Data on the effects of ionizing radiation on the central nervous system are reviewed. Topics discussed include the mechanism of the action of ionizing radiation on neurons; radiation effects on the developing nervous system in embryos and fetuses and on the nervous system in young and in mature animals; the effects of radiation dose, acute or whole-body exposure on the nervous system; clinical symptoms indicating nervous system involvement in acute radiation sickness; the radiosensitivity of the cerebral hemispheres, the hypothalamus, and the spinal cord; the action of radiation as a general non-specific stimuli; and the participation of the nervous system in reactions of the entire organisms, or of its specific systems, especially the gastrointestinal tract, hematopoietic system, endocrine glands, regulation of the cardiovascular system, regulation of functions of the gastrointestinal tract, alteration of tissue trophics, and alterations in the permeability of blood vessel membranes. (499 references.) (C.H.)

**1794** (BNL-10449) AGING STUDIES IN A MARSHALLESE POPULATION EXPOSED TO RADIOACTIVE FALLOUT IN 1954. Conard, Robert A.; Lowrey, Austin; Eicher, Maynard; Thompson, Keith; Scott, William A. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 31p. (CONF-660635-1). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From International Colloquium on Radiations and Aging, Semmering, Austria.

Late effects of radiation observed in March, 1966 in a Marshall Island population accidentally exposed to radioactive fallout in 1954 are reviewed. The most significant findings are the development of thyroid abnormalities which have occurred largely in children exposed at less than 10 years of age, and presumably caused by $\gamma$ rays and irradiation of the thyroid gland from internal absorption of radioiodines in the fallout. Possible radiation induced aging effects were studied in 90 adults, 36 exposed and 55 unexposed by measurement of 14 criteria usually associated with aging [skin elasticity and looseness; hair greyness; accommodation, visual acuity, and arcus senilis of the eyes; hearing loss; nervous and neuromuscular function and vibration sense; light extinction test; rapid movement test; hand grip strength; systolic blood pressure; blood cholesterol level; and body potassium ($^{40}$K)]. Analysis of variance was used to determine correlation with age and the data for each criterion were weighted according to this correlation factor. Combined scores for all criteria gave a measure of physiological age as compared with chronological age on an individual and group basis. Most of the criteria showed good correlation with age on a group basis, less so on an individual basis. Between 20 and 40 years of age the criteria showed less change than after that age. No significant differences were noted between the exposed and unexposed groups. It was postulated that if there were aging effects from the dose of radiation received by this population more sensitive tests would be necessary to show them. (auth)

**1795** (BNL-10564) RADIATION AND AGING. Curtis, Howard J. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 25p. (CONF-660908-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Society of Experimental Biology, Aspects of the Biology of Ageing, Sheffield, England.

Aging can be defined as an increasing probability for the individual to contract one of the degenerative diseases. It can be shown that most, if not all, of these diseases probably involve one or more mutations in a somatic cell. Radiation is the most effective mutagenic agent known and also hastens the appearance of all of these diseases. Further, different kinds of radiation and radiation regimes shorten the life span of mice by an amount proportional to the number of mutations each of these treatments produce. These facts greatly strengthen the mutation concept of aging and promote the idea that radiation accelerates the aging process. The entire process of aging is considerably broader than the rather pragmatic definition adopted here. If one considers all the various age-related phenomena it is quite clear that many of them are quite unaffected by even rather large doses of radiation. Thus aging is a very complex biological process, and no single, simple theory will explain it, and no single agent could possibly be expected to affect all parts equally. (auth)

**1796** (CEA-R-3007) CHROMOSOMES ET RADIATIONS: ETUDE IN VITRO DE L'ACTION DES RAYONS X SUR LES LYMPHOCYTES HUMAINS. (Chromosomes and Irradiation: In Vitro Study of the Action of X-Rays on Human Lymphocytes). Mouriquand, Claude; Patet, Janine; Gilly, Claudine; Wolff, Charlotte (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). June 1966. 36p. Dep. mn.

Radioinduced chromosomal aberrations were studied in vitro on leukocytes of human peripheral blood after x irradiation at 25, 50, 100, 200, and 300 R. The numeric and structural anomalies were examined on 600 karyotypes. The relationship between these disorders and the dose delivered to the blood are discussed. An explanation on their mechanism of formation is tentatively given. (auth)

**1797** (IAN-A-3) EFFECTO DE LAS RADIACIONES GAMMA SOBRE LA LONGEVIDAD Y LA MORFOLOGIA DEL SACODES PYRALIS DYAR. (Effect of Gamma Radiation on the Longevity and Morphology of Sacodes Pyralis Dyar). Uribe, Ruby Londono (Instituto de Asuntos Nucleares, Bogota (Colombia). Division Reactor). 1965. 68p. Dep. mn.

The effects of $\gamma$ irradiation at doses of 5,000, 10,000, and 20,000 RAD applied 6 and 12 days during the pupal stage was studied in Sacodes pyralis. The criteria used to evaluate the effects of radiation were the life spans of the pupal and adult stages, the modalities of emergence of the adults, and the morphological and physiological conditions of both sexes. All numerical data were analyzed statistically. The results indicated that 5,000 rad dose did no injuries to the pupae whether irradiated on the sixth or twelfth day. Doses of 10,000 and 20,000 rad resulted in injuries to the pupae irradiated at the sixth day For pupae irradiated on the twelfth day, there was a considerable difference between the effects on the different sexes. The age of the chrysalis at the moment of irradiation and the radiation dose appeared to be factors controlling the magnitude of the radiation effects in each of the sexes. The dose required for permanent sterility was not determined, however, there was evidence that the radiation required would be less than that necessary to inhibit the ovipository capacity of the females. (60 references) (tr-auth)

**1798** PREVENTION, DIAGNOSIS, AND TREATMENT OF BLADDER LESIONS DUE TO RADIATION THERAPY. Cavazzana, P.; Sesenna, R.; Germinale, T.; Pontiggia, F.; Pistolesi, G. F.; Ravasini, R. Minerva Urol., 17: 132-6(July-Aug. 1965). (In Italian).

When pelvic radiation therapy is used, particularly for uterine cervical cancer, to the limiting dose of healthy tissues, some injury to bladder epithelium is to be expected and is an acceptable hazard in attempting to eradicate the cancer. However, some prophylactic and therapeutic means can be taken to block the progression of injury from necrosis, ulceration, and fistulation. Bladder mucosa is especially radiosensitive. Doses as low as 500 to 1000 rad cause early erythema, and, with higher doses there is increasing cellular erosion. The basement membrane is resistant to radiation as is the submucosa. Proliferation of connective tissue and resultant fibrosis follows the destruction of epithelium. Cystoscopy is an important means of detecting early radiocystitis and allowing prompt treatment, which for mild cases consists of medication. Late, more serious lesions may require surgery. Surgical repair of the bladder is described. Also discussed are the symptomology, clinical signs, and progressive stages of radioinduced lesions of the bladder. (BBB)

**1799** RADIATION INVESTIGATION OF MORPHOGENETIC FUNCTION OF THE NUCLEI IN TISSUE DIFFERENTIATION IN EARLY DEVELOPMENT OF FISH EMBRYO (LOACH, MISGURNUS FOSSILIS). Korolev, M. B.; Neifakh, A. A. (Severtsov Inst. of Animal Morphology, Moscow). Zh. Obshch. Biol., 26: 352-7(1965). (In Russian).

Histological study of loach embryos with inactivated nuclei at subsequent developmental stages was carried out in order to investigate the morphogenetic function of the nuclei in particular embryonic anlages. Radiation inactivation (40 kr) of the nuclei was used. Morphogenetic function of the nuclei in particular embryonic anlages is shown to occur periodically. The intensity of nuclear function at the same time appears to differ in different anlages. This difference appears to increase during differentiation. The radiation damage of cell nuclei at different developmental stages has been also described. (auth)

**1800** QUALITATIVE CHANGES IN BLOOD GLUCOSE OF RATS IRRADIATED WITH $^{60}$Co GAMMA RAYS. Zamurovic, D.; Zecevic, V.; Milosevic, M. (Medical Coll., Belgrade). Arh. Farm. (Belgrade), 15: 191-7(1965). (In Croatian).

Glucose blood levels were measured in 88 rats 5, 15, 30 minutes, 1 and 2 hours and 1, 2, 5, 15 and 30 days after whole-body irradiation with 600 to 1100 R $^{60}$Co $\gamma$. In general, there was a fall in blood glucose proportional to the dose in both intensity and duration.

There was a slight excess of glycemia with low doses of irradiation following the initial slight fall. (JPRS)

**1801** FREE RADICAL PROCESSES IN THE TISSUES OF IRRADIATED ANIMALS. Taranenko, G. A.; Kozlov, Yu. P.; Burlakova, E. V. Nauch. Dokl. Vyssh. Shkoly, Biol. Nauk., No. 1, 82-6 (1966). (In Russian).

The effects of whole-body doses of 600 and 1500 R $\gamma$ radiation on free radical formation in mouse tissues were investigated by studies of copolymerization of $^{14}C$-acrylamide given intraperitoneally before, or up to 8 days following, radiation exposure. The copolymerization of acrylamide was evaluated by radiometric and autoradiographic methods in tissues of mice killed 4 hr after acrylamide administration. X irradiation caused an increase in the content of free radicals in the liver, kidneys, and blood plasma, a decrease in free radical content in the spleen, and no change in the free radical content of erythrocytes, brain, and muscles. Free radical content of the tissues returned to normal 6 to 8 days after exposure to 600R, but no regeneration of free radical processes was observed in animals exposed to 1500R x radiation. (C.H.)

**1802** PROGRESSIVE THORIUM DIOXIDE MYELOPATHY. Maltby, George L. (Maine Medical Center, Portland). New Eng. J. Med., 270: 490-6(Mar. 5, 1964).

Progressive cauda-equina syndrome was observed in 3 patients who had been subjected to thorium dioxide (Thorotrast) myelography in the early 1940's. Damage is attributed to radioactivity of thorium dioxide and its progressive injurious effect. The dangers of thorium dioxide and its daughter products are much greater than imagined at the time when it was being used freely in the central nervous system, and calculations of the amount of material removed by the so-called forced-drainage method were definitely in error. All three patients had shown a severe and immediate systemic reaction, especially in temperature, after myelography and forced drainage. This cleared in a few days, and there was no apparent effect from the retained material for an average interval of eight years. A progressive crippling cauda-equina syndrome then ensued, motor symptoms appearing first, with stiffness, weakness, and progressive paralysis. Deep tendon reflexes disappeared. In two cases pain was severe and progressive. In two cases hypesthesia and paresthesia also appeared. The sensory changes were those of a peripheral or caudal lesion. In all three cases symptoms of neurogenic bladder appeared, and in two, secondary recurrent infection in the urinary tract was the major contributory factor to death. (TCO)

**1803** MASSIVE UTERINE NECROSIS FOLLOWING IRRADIATION FOR EARLY CERVICAL CARCINOMA IN PREGNANCY: REPORT OF A CASE. Barchet, Stephen; Janovski, N. A. (Naval Hospital, Beaufort, S. C.). Med. Ann. Dist. Columbia, 35: 71-4 (Feb. 1966).

After discovery of squamous cell carcinoma of the cervix in a 38-yr-old pregnant patient, therapeutic abortion was performed. Ten days later radium applications were given. Radium application was repeated 9 days later. According to calculations, 7000 R was administered to point A, 2340 R to point B, and 10,800 R to the cervix. One month following the second radium application, when bilateral extraperitoneal pelvic lymph-node dissection was performed, histopathologic examination revealed only reticuloendothelial hyperplasia of lymph nodes. Simple abdominal hysterectomy and bilateral salpingo-oophorectomy were performed later. The extensive radioinduced necrotic changes in the uterus are described in detail. Careful examination of uterus removed postirradiation should be mandatory for the establishment of adequate statistical data. The lack of available pathologic and radiologic literature reports indicates that such specimens are rare or myometrial radionecrosis has not been evaluated in a proper clinical light. Statements such as the "tolerance of the myometrium to irradiation is practically limitless" of "the myometrium will tolerate 20,000 R responding with simple atrophy" are arbitrary. Biologic processes occurring in the myometrium following irradiation particularly when the myometrium has been hormonally stimulated, as in pregnancy, or surgically manipulated prior to irradiation need to be investigated. (TCO)

**1804** STUDIES OF THE RADIATION EFFECTS ON CELLS. III. ELECTRON-MICROSCOPE STUDIES ON THE FINE STRUCTURE OF ASCITES TUMOR CELLS AFTER X IRRADIATION. Morimoto, Hiroyoshi (Tokushima Univ., Japan). Shikoku Igaku Zasshi, 16: 390-5(Feb. 1960). (In Japanese).

Morphological changes in MTK-III ascites sarcoma cells after x irradiation in vitro and in Wistar rats were observed in the electron microscope by the ultra-thin section technique. Swollen mitochondria, fragmented crista mitochondriales, and matrix of decreased density were detected soon after irradiation in vivo. These changes disappeared within several hours after irradiation. The endoplasmic reticulum could be seen more clearly soon after irradiation and its normal state was recovered rapidly (after a few hours). These changes were observed in the cells after 200-R irradiation. After 1000-R irradiation, the described irradiation effects increased markedly. In experiments in vitro, swollen mitochondria, broken crista mitochondriales, and decreased density of matrix were also found. The same changes in the endoplasmic reticulum were detected after irradiation. These changes did not disappear after irradiation, indicating that the cells did not recover from the effects of high-dosage x irradiation. The observed changes in mitochondria post-irradiation are correlated with results of biochemical studies revealing impairment of oxidative phosphorylation. (BBB)

**1805** RATE OF HEALING OF WOUNDS TREATED WITH ULTRA-VIOLET LIGHT. Brockis, J. G.; Elliott, M.; Lissiman, M. (Univ. of Western Australia, Perth). Austral.-New Zeal. J. Surg., 35: 108-14(Nov. 1965).

The effect of uv light on healing of skin wounds in mice was studied. A circle of skin with a dia of 1 cm was removed from the back of each mouse. After 24 hr all the wounds were covered with dry scabs. Some of these were raised and a drop of a heavy broth culture of staphylococci introduced. Forty-eight hr later the scabs were removed from some animals. A swab was taken for culture purposes and the wounds were then subjected to treatment with uv light from a Kromayer lamp through a quartz applicator for 8.5 min, a time found experimentally to produce a vesicle on intact skin. The amount of radiation given corresponded to a fourth degree erythema dose. This dose was shown to be bactericidal to staphylococci and to produce slight vesiculation when applied to the bare skin of a mouse. The results showed that in the mouse, wounds heal more slowly if treated with uv light. The difference between the treated and untreated wound is statistically highly significant. Both groups which received uv light therapy, showed delayed healing of wounds. At the end of ten days only one out of 24 wounds had healed compared with 6 in the groups not receiving therapy. The results were more striking if wounds in which 5% or less of the total size remaining unhealed after ten days were included. Twenty-one of 24 wounds in the control groups had reached this level of healing, but only one of 24 in the groups subjected to uv light therapy. Many of the latter were still not healed after two weeks. Wounds which were deliberately infected with staphylococci also showed delayed healing, an effect which was additional to that caused by uv light and apparently produced by a totally different mechanism. Wounds which were not deliberately contaminated with staphylococci sometimes became mildly infected during the healing period; nevertheless, they healed more rapidly than those which had been deliberately inoculated with organisms. (BBB)

**1806** MATERNAL RADIATION AND DOWN'S SYNDROME (MONGOLISM). Carter, C. O. (Inst. of Child Health, London); Evans, K. A.; Stewart, A. M. Lancet, 2: 1042(Nov. 4, 1961).

Comments are made on the report of Uchida and Curtis on possible association between maternal abdominal radiation and mongolism. It is pointed out that there is a danger, especially with a topical investigation of this kind, that several groups may make a similar study and only those with a positive finding publish their results. The present authors made a similar study wherein 51 patients with Down's syndrome (mongolism) were matched for year of birth (within a year), maternal age (within 15 months), and birth order, with 51 control patients with central nervous system malformations (18), congenital heart malformations (18), and congenital dislocation of the hip (15). An investigator visited the homes and took a detailed history of the radiation experience, before and after the conception of the index patient, of both parents. No significant or even suggestive differences were found between the radiation exposure of the parents of children with Down's syndrome and the parents of the control patients. The information of the preconception abdominal radiation of the mothers, tabulated as in the report of Uchida and Curtis, is shown. (BBB)

**1807** EARLY EFFECTS OF WHOLE-BODY IRRADIATION ON THE HYPOTHALAMIC-HYPOPHYSEAL TRACT AND THE PINEAL BODY OF THE RAT. Duchesne, P. Y.; Beaumariage, M. L. (Univ., Liege). Bull. Cl. Sci., Acad. Roy. Belg. (5), 51: 1340-3(1965). (In French).

Examination of the hypothalamic-hypophyseal tract at various time intervals following lethal doses (800 R) of whole-body irradiation revealed a stimulation of the hypothalamic response and activation of neurosecretion. The response is maximal at two hrs post-irradiation but is detectable at the time of removal from the irradiation facility, 8 min after the onset of irradiation. This early response to the stress of irradiation is confirmed by the suppression of activity during the same period in the pineal gland. Diencephalic modifications correspond to those in the adrenal cortex in respect to time. (H.G.D.)

**1808** GROWTH OF DIETHYLNITROSAMINE-INDUCED LUNG TUMOURS IN SYNGENEIC MICE PRETREATED WITH X-RAY KILLED TUMOUR TISSUE. Pasternak, G.; Hoffman, F.; Graffi, A. Folia Biol. (Prague), 12: 299-304(1966).

X irradiated tissue suspensions of six diethylnitrosamine-induced lung tumors of mice were tested for specific immunogenicity in syngeneic recipients. Pretreated animals did not develop transplantation resistance against challenge injection with living cells of the same tumor. Whereas two of the six tumors tested were slightly inhibited in their growth when injected into specifically pretreated animals, the growth of two other tumors was enhanced. Two tumors grew almost equally well in both untreated and pretreated animals. (auth)

**1809** STUDIES OF SPERMOGRAM OF PERSONS PROFESSIONALLY EXPOSED TO IONIZING HAZARDS. Vaskov, L.; Gospodinova, D. (Research Inst. of Radiology and Radiational Hygiene, Sofia). Compt. Rend. Acad. Bulg. Sci., 19: 325-8(1966).

Effects of long-term occupational exposure to low doses of ionizing radiations were studied in 104 men ranging in age from 20 to 43 yrs. A statistically significant reduction on the percentage and the total number of mobile spermatozoa was established in the spermogram of these individuals. Morphological investigations did not reveal any significant differences between personnel groups and controls. Changes in spermograms were particularly pronounced in persons with radioinduced hematopoietic depression. (H.G.D.)

**1810** ACTIVITY OF ALANINE- AND ASPARTATE-AMINOTRANSFERASE IN YOUNG RATS AFTER X IRRADIATION. Pikulev, A. T.; Smelyanskaya, G. N. (Lenin Belorussian State Univ., USSR. Inst. of Physiology, Academy of Sciences, Belorussian SSR). Ukr. Biokhim. Zh., 38: 383-8(1966). (In Russian).

It was found that under the effect of irradiation with x rays in a dose of 100 R the rate of enzymatic transamination from L-alanine and L-aspartic acid to $\alpha$-ketoglutaric varies in different divisions of the central nervous system and in the skeletal muscle during all periods of the investigation. The greatest changes in alanine-aminotransferase activity is observed in the skeletal muscle, and in aspartate-aminotransferase activity, in the skeletal muscle and cerebellum. Disturbance in the rate of enzymatic transamination on irradiation with x rays is affected, along with other factors, by the age of the animal. (auth)

**1811** COMPARATIVE STUDY OF THE EFFECT OF X IRRADIATION AND RADIOMIMETIC EMBYTOL PREPARATION ON THE ACTIVITY OF SOME AMINOTRANSFERASES. Tsybulskii, V. V. (Pirogov Medical Inst., Odessa). Ukr. Biokhim. Zh., 38: 410-18(1966). (In Ukrainian).

Distinctions and similarities are noted in the effect of x irradiation (900 R) and embytol haloidalkylamine (12.4 mg/kg) on aspartate- and alanin-aminotransferase in the organs and tissues of the rabbit (marrow, spleen, small intestine, liver, and brain). Similarities were found in the phase changes of the activity of both enzymes, in the organic (tissue) specificity of the enzymatic reactions, in the common sensitivity of the enzymes to the effect of the radiation and chemical factors, especially in the organs sensitive to radiation, in the effect of both agents on the liver enzymes (a rise in activity) and, finally, in the absence of essential differences (with the exception of the liver) in the enzymatic reactions of the early period (first day). The differences consist in the various periods during which phase changes occur, in the magnitude, duration, and predominant tendencies of the changes due to each of the acting factors. On irradiation AST activity is reduced in most organs (the maximum occurs after seven days). Under the effect of embytol the activities of both aminotransferases are raised (the maximum occurs on the fifteenth and seventh days). (auth)

**1812** AN ATTEMPT AT IN VITRO SENSITIZATION OF IMMUNOLOGICALLY COMPETENT CELLS AGAINST TUMOR SPECIFIC ANTIGEN. Koldovsky, P. (Imperial Cancer Research Fund, London). Folia Biol. (Prague), 12: 238-47(1966).

The possibility of sensitizing immune cells in vitro against tumor specific antigen was studied. This phenomenon is not limited to one tumor but, as the same results were obtained with 11 other tumors in various strains of mice, it seems to be a more common phenomenon. The effect of adding specific antiserum to the immune cells before treatment, or immediately after mixing with tumor antigen to prevent the inhibitory effect on tumor growth of in vitro sensitized cells, shows that a functional interaction of immune cells and tumor antigen must play an important part. When lethally x irradiated mice have been protected with cells sensitized in vitro against tumor antigen, such animals have been resistant to a graft of the corresponding tumor. Animals injected with in vitro sensitized immune cells react against tumor antigen in the secondary type of immunological response. Cells of such animals in adoptive transfer also show an immune capacity which corresponds to the second type of response. The cells from specifically tolerant animals or from those lethally irradiated 24 hours previously lose the capacity to be sensitized in vitro. (auth)

**1813** EXPERIMENTAL STUDIES ON THE ANTIGENICITY OF ORGANS AND SERUM OF X-RAY IRRADIATED ANIMALS IN THE HOMOLOGOUS ANIMAL. PART II. STUDIES ON THE HOMOLOGOUS ANTIGENICITY OF THE SERUM OF THE RABBIT PRETREATED BY X IRRADIATION OF LIVER. Sakakura, Takehiko (Mie Prefectural Univ., Tsu, Japan). Arerugi, 15: 84-90(Feb. 1966). (In Japanese).

The serum of rabbits, which received 12 daily doses of 500 R to the liver for 12 days to give a total of 6000-R liver dose, was injected in other, normal rabbits to test for possible changes in its antigenicity. Formation of complement-fixing antibody and antileukocyte antibody in the serum was seen, although antibody titer was rather low. Consequent disturbances of liver function and allergic histological changes chiefly localized in the liver were also noted. In the blood of the rabbit sensitized with the x-irradiated serum, it was possible also to demonstrate the complement-fixing antibody and the antileukocyte antibody which were formed in response to injection of irradiated liver emulsion. Paper-electrophoretically, the site of peak concentration of the irradiated liver emulsion protein coincided with that of the $\beta$-globulin fraction of the serum of irradiated rabbits. It is suggested that irradiation of the liver induced the denaturation of the rabbit's own protein, possibly at the time of protein synthesis in the liver, resulting in homologous antigenicity of the serum. Furthermore, irradiation also apparently caused liberation of the denatured liver tissue protein into the bloodstream, migrating in the $\beta$ fraction of serum protein, and resulting in allergic changes selectively localized in the liver. (BBB)

**1814** SOME EXPERIENCES WITH EXPERIMENTAL BRAIN GLIOMAS IN MICE. Davidoff, Leo M. (Yeshiva Univ., New York). Israel J. Med. Sci., 1: 633-42(July 1965).

The effects of x rays and antitumor immunization on intracerebrally inoculated gliomas in C57B1/6J mice were studied. Immunization of the mice with the tumor plus Freund's adjuvant before implantation of the glioma into the brain of the same animals caused the tumor to be rejected by a significant percentage of mice, as demonstrated by the survival of most of them beyond 28 days, and the histological disappearance of the implanted neoplasm from the brain. Immunization after implantation was ineffective in protecting the animals against the neoplasms. Tumor x-ray doses of between 1100 and 1840 R, divided into five doses and given between 10 and 26 days after implantation of the tumor into the brain, retarded tumor growth and thus prolonged the life of the animals over the controls, but seldom completely eradicated the tumor. When the total dose was increased to 2200 to 3000 R, the tumor was eliminated in most mice without any serious effects on the animals themselves. A dose of 3500 R or more was lethal to the animals. The rate of delivery of radiation was an important factor in the overall effect on the mice. When five doses adding up to 3000 R were delivered to the animals' heads, the animals began to look ill about 30 days after the first dose. However, after about 10 days more they recovered. When higher total doses were used, these symptoms were more exaggerated, and the animals died. Histologically, the brains of x-ray-treated mice two days later showed widespread early degeneration of neoplastic cells. As therapy continued, these changes became intensified. When an overdose of radiation of 3500 R or more was used, the animals died and their tumors were found to be necrotic, but their brains were remarkably free from detectable damage. However, tissue damage was found in the lungs. It thus appears that death was due to radiation effects upon organs adjacent to the brain which could not be adequately shielded, rather than to radiation effect on the brain itself. (TCO)

**1815** CHANGES IN SERUM ENZYMES FOLLOWING PELVIC LYMPH NODE THERAPY WITH $^{131}$I. Grella, P. (Univ., Padua). Attual. Ostet. Ginecol., 9: 880-2(July–Aug. 1963). (In Italian).

Changes in the serum activity of malic dehydrogenase (MDH) and lactic dehydrogenase (LDH) were studied in patients with gynecologic cancer being treated by intralymphatic injections of $^{131}$I-Lipiodol for metastases to the lymph nodes. Most patients were classified as Stage II uterine cervical carcinoma. Doses of $^{131}$I varied from 7 to 25 mC. Serum samples for enzyme assays were taken before intralymphatic infusion of the radioisotope and three days afterward. Serum MDH activity showed a 71% increase as a result of $^{131}$I therapy, rising from 117 units/ml initially to 200 units/ml three days later. Serum activity of LDH increased 45% (192 before 275 units/ml after treatment). Seven to 10 days later the serum enzyme activities had returned to near-normal levels. It is suggested that the post-irradiation increases of MDH and LDH activities reflect tissue damage from the isotope. (BBB)

**1816** ENZYMATIC ALTERATIONS IN BLOOD IN THE COURSE OF RADIOISOTOPE LYMPHOGRAPHY. Grella, P.; Cerutti, R. (Univ., Padua). Attual. Ostet. Ginecol., 11: 92-8 (Jan.–Feb. 1965). (In Italian).

In patients with gynecologic cancer, serum activities of glutamic-oxaloacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), and isocitric dehydrogenase (ICDH) were determined before and after radioisotope lymphography. Metastatic cancer in the lymph nodes was treated by injections of $^{131}$I-labeled Lipiodol. This isotope provides 90% of its radiation as $\beta$ rays with a range of 3 mm in tissue and 10% as $\gamma$ rays. Results are given for serum enzyme activities before, 3 days after, and 5 days after intralymphatic infusion of $^{131}$I-Lipiodol. Serum GOT activity rose from 31.8 units/ml to 50.5 and 59.6 units/ml after treatment. Activity of GPT rose slightly (from 22.3 to 30.3 and 39.8 units/ml). Activity of ICDH rose slightly but not significantly (from 224 to 256 and 245 units/ml). It is suggested that the increases of GOT and GPT activity in serum reflect cytopathologic effects caused by $^{131}$I in the lymph nodes. (BBB)

**1817** TRANSPLANT IMMUNITY IN ANIMALS WITH LYMPHOCYTOPENIA INDUCED BY INDWELLING BETA IRRADIATION. Wolf, James S.; Hume, David M. (Medical Coll. of Virginia, Richmond). Contracts AT40-1(2459); HE-08203; T-166D. Surg. Forum, 16: 202-4(1965).

Intra-arterial irradiation of circulating blood with beta emitting $^{90}$Y silica coated pellets produced lymphocytopenia in dogs, which persisted after the acute radiation period. The radiation-induced lymphopenia caused immune responses to be weakened with respect both to foreign protein and organ homografts. (C.H.)

**1818** THE IMPORTANCE OF TEETH IN OSTEORADIONECROSIS OF THE MANDIBLE (AND WHAT THE RADIOTHERAPIST MUST KNOW). Hauser, Paul (Johann Wolfgang Goethe Univ., Frankfurt am Main). Radiologe, 4: 339-4(Oct. 1964). (In German).

The integrity of the dental system is important both for the appearance and for the prevention of osteoradionecrosis of the jaw. The usual sequence of events after areas in the region of the lower jaw are irradiated is that when pains occur in the area several years afterwards the teeth believed to be responsible are extracted. It is from this time on that clinical symptoms of osteoradionecrosis generally appear. It is preferable to remove all devitalized or unusable teeth and their roots prior to the irradiation so that they do not become foci of infection after irradiation. Generally, after irradiation, teeth become brittle and susceptible to caries, possibly because of reduced salivary flow caused by the irradiation. Loss of the teeth frequently may also favor infection of the bone. If the defective teeth are removed before irradiation, the irradiation should be delayed for 8 or 10 days to reduce the chance of subsequent infection. (BBB)

**1819** INFLUENCE OF COLLECTION FREQUENCY ON POST-IRRADIATION SPERM OUTPUT BY RABBITS. McFee, A. F.; Eblen, J. R.; Welch, P. R. (Univ. of Tennessee, Oak Ridge). J. Reprod. Fertil., 11: 287-9(Apr. 1966).

In studies on the effect of irradiation on testicular function it is important to know the frequency with which ejaculates must be taken to establish accurately the postirradiation pattern of sperm output. Thus determinations were made of whether or not an increased frequency of collection yielded more reliable results than the once-a-week practice normally employed. Little increase in total sperm output during 3-week collection periods was found when two ejaculates were taken every 2nd day rather than every 3rd day, indicating that two ejaculates taken every other day harvested spermatozoa as fast as they were produced. A 600-R dose of $\gamma$ radiation was administered to the testes of male rabbits. On the day following irradiation, a single ejaculate was taken from each male in Group I and two ejaculates from those in Group II. During the ensuing 16 weeks one ejaculate a week was obtained from males in Group I while two ejaculates, ~30 min apart, were taken every 2nd day from those in Group II. The results indicated that increasing the frequency of collection beyond once a week offers little opportunity for detecting irradiation damage any earlier in the postexposure period. Although the level of minimum sperm output was reached a few days earlier as a result of more frequent collection, the decline began at about the same time and proceeded at similar rates in the two groups. The 2-day group approached azoospermia a few days earlier. More frequent collection offered no appreciable advantage in establishing the rate of recovery of sperm production by irradiated animals. To obtain the maximum number of spermatozoa from test animals in a given period or in closely following day-to-day changes, more frequent collections are desirable. (BBB)

**1820** CLINICAL-ANATOMICAL OBSERVATION OF A CASE OF CEREBRAL RADIONECROSIS. Toga, M.; Berard, M.; Sommer, D. (Faculte de Medecine, Marseille). Arch. Anat. Pathol. Semaine Hop., 11: 175-80(Sept. 1963). (In French).

A case history, with histologic study, of a patient who developed brain injury from therapeutic irradiation is reported. The 48-yr-old woman was treated for a meningioma of the right frontal lobe which caused an osteolytic lesion. Intensive radiation therapy through four portals was given to deliver a total dose of 10,000 R. Six yr later hemiplegia on the left side developed, associated with signs of a diffuse lateral disorder. Encephalography revealed an expanding lesion thought initially to represent a tumor recurrence. However, surgical intervention revealed a necrotic, hemorrhagic process in cerebral parenchyma. Biopsies of this tissue were examined microscopically. The cerebral lesion was exclusively in the white matter. Marked vascular changes were noted, including hyaline sclerosis, fibrinoid degeneration, and endarteritis. Obliteration of the blood vessels by these processes was evidently responsible for the ischemic origin of the symptoms. Vascular permeability disorders were the cause of edema and extravasation of plasma proteins into the tissues. Some areas had a para-amyloid appearance. The delay of 6 yr in appearance of the lesion postirradiation suggests that an autoimmunologic reaction may have been important in its pathogenesis. (BBB)

**1821** EFFECT OF X RAYS ON POSTNATAL TESTIS DEVELOPMENT AND GERM CELL MATURATION IN THE MOUSE. Widmaier, Renate (Martin-Luther-Univ., Halle/Saale, Ger.). Z. Mikroskop. Anat. Forsch., 71: 229-55(1964). (In German).

Mice were irradiated within 12 hr of birth with a whole-body dose of 570 to 800 R, killed at later intervals of from 1 to 50 days, and their testes examined histologically. As compared to control animals, the testes of the irradiated animals remained small. The fertile tubuli contorti reached almost the same width as normal tubuli. The length of growth of the canaliculi was greatly reduced. The fractions of fertile and sterile tubuli that were removed from a section of testis varied greatly. The fertile canaliculi amounted to $\frac{1}{2}$ or $\frac{3}{4}$ of the total. The first spermatogenesis cycle, which normally begins right after birth in the mouse, was delayed ~5 days after irradiation. In addition, the degeneration of the primordial sex cells occurred ~5 days later than normal, and some of these cells were retained for a very long time. Spermatocyte formation and maturation division were the developmental stages in which most of the spermatogenic cells died after irradiation. The development of Sertoli cells was delayed less than 5 days. The opening of the canaliculi lumens began with a delay of more than 5 days. The radiation injury of the testis was greater in newborn mice than in adult animals. Close to 90% of the surviving irradiated animals were fertile. References cited, 45. (BBB)

**1822** REJECTION OF ALLOGENIC SKIN GRAFTS AND PRODUCTION OF ISOHEMAGGLUTININS BY SENSITIZED MICE AFTER SUBLETHAL IRRADIATION. Tyan, Marvin L.; Cole, Leonard J. (Naval Radiological Defense Lab., San Francisco). J. Immunol., 95: 945-50(Nov. 1965).

Sublethally irradiated mice previously sensitized by several methods were grafted following irradiation. Twelve-week-old male (C57Bl/6xDBA/2)$F_1$ mice were used as recipients, and tissue for sensitization was obtained from female A/HeJ mice. Skin graft donors were male mice of the strains (C57Bl/6xDBA/2)$F_1$, A/HeJ, and A.CA. One week after the last injection of spleen cells (day 0) the mice received 670-rad whole-body x radiation. These mice and their nonirradiated controls were grafted on either day 30 or 61. In nonirradiated mice sensitization with a skin graft produced the most persistent state of homograft sensitivity, while sensitization with spleen cells in Freund's complete adjuvant induced the highest and most persistent hemagglutinin titers. The homograft sensitivity induced by the subcutaneous injection of spleen cells alone or in adjuvant waned with time. At the times tested there was no evidence of homograft sensitization in the groups which received multiple intraperitoneal injections of spleen cells. Sublethal x irradiation produced max depression of hemagglutinin titers between days 7 and 15; recovery of this manifestation of sensitization was usually evident by the 22nd day following irradiation. Sensitization with an emulsion of spleen cells and Freund's complete adjuvant produced the most radioresistant hemagglutinin responses. Hemagglutinin titers following recovery from irradiation were lower than in the comparable nonirradiated groups; however, the secondary responses were usually as vigorous. Some of these data suggest that hemagglutinin production and homograft sensitivity are mediated by separate products of cell differentiation, perhaps distinct cell populations. (BBB)

**1823** NEW DATA ON THE EFFECTS OF IONIZING RADIATION ON RADIOLOGISTS. Warren, Shields; Lombard, Olive M. (New England Deaconess Hospital, Boston. Harvard Cancer Commission, Boston). Arch. Environ. Health, 13: 415-21(Oct. 1966).

The average age at death of U. S. radiologists in the past has been younger than that of other physicians or U. S. adult white males. Since 1935 this evidence of life shortening has lessened, most strikingly since 1945, and disappeared by 1960. Leukemia, though excessive among radiologists, occurs rarely and apparently only after a number of years of occupational exposure. The age

pattern of the incidence of leukemia is quite different in radiologists and U. S. white males over age 25. In recent years the excessive incidence of leukemias in radiologists has decreased. From these findings one may conclude that current occupational maximal permissible dose levels provide adequate protection. (auth)

**1824** EFFECT OF X-IRRADIATION ON THE INSECT SENSITIVITY TO INSECTICIDES. Vashkov, V. I.; Poleshchuk, V. D. Zh. Mikrobiol., Epidemiol. Immunobiol., No. 8, 9-11(Aug. 1966). (In Russian).

The effect of x irradiation on the sensitivity to DDT, hexachlorane, and chlorophos was studied on 5-day-old domestic flies (females). Sensitivity of the flies to insecticides changed in relation to the x ray dose absorbed. After the irradiation there was an increase of sensitivity to the insecticides as compared to controls. The maximal fly sensitivity to insecticides was observed after the action of x ray doses of 10,000 to 30,000, and 40,000 rad. (auth)

**1825** COMPARISON OF DIRECT AND INDIRECT EFFECTS OF ALKYLATING AGENTS AND RADIATION ON MURINE LEUKEMIA CELLS IN VITRO. Goldenberg, Gerald J. (Univ. of Manitoba, Winnipeg. Manitoba Cancer Foundation, Winnipeg). Nature, 211: 427-8(July 23, 1966).

The direct effects of dimethyl myleran (DMM), nitrogen mustard ($HN_2$), and $^{60}Co$ gamma rays on murine leukemic lymphoblasts in vitro was compared with their indirect effect on the tissue culture medium. Lymphoblast cells were added to DMM-treated medium at 240 min, to $HN_2$-treated medium at 300 min, and to irradiated medium at both 2 and 240 min post-irradiation. No cytocidal effects were observed when the cells were introduced into the medium 24 min after DMM and 300 min after $HN_2$. A complete absence of cytocidal action was also observed when cells were added to medium 2 and 240 min after irradiation. It appears that a cytocidal effect following treatment with DMM, $HN_2$, and ionizing radiation represented a direct effect on the cell by DMM, $HN_2$, and gamma rays and did not involve any sustained indirect effect. (H.G.D.)

**1826** CHANGES IN CONDITIONED REFLEX ACTIVITY OF DOGS UNDER THE INFLUENCE OF SMALL DOSES OF RADIOACTIVE $^{24}Na$ FOLLOWING A PRELIMINARY ADMINISTRATION OF ALCOHOL. Shal'nev, B. I. Zh. Vysshei. Nerv. Deyatel'nosti, 15: 445-52(1965). (In Russian).

A study was made of the action of indicator doses (5 microcurie/kg) of radioactive sodium-24 on higher nervous activity of dogs with and without a preliminary administration of 30 ml of 96% ethyl alcohol. The doses of isotope cause marked functional shifts in the cerebral cortex expressed in a weakening of the internal inhibition. The action of small doses of internal irradiation on a functionally changed cerebral cortex has resulted in more considerable changes in conditioned activity: a wave-like course of conditioned reflexes, disinhibition of differentiations and development of phasic conditions. These disturbances lasted for 16 to 20 days. (auth)

**1827** HISTOLOGICAL CHANGES OF THYROID GLAND AFTER INJECTION OF RADIOACTIVE RAIN-WATER INTO PREGNANT MICE. Muto, Tatsukichi (Mie Prefectural Univ. School of Medicine, Tsu, Japan). Mie Kaibo Gyosekishu, 14: No. 6, 1-8 (1963). (In Japanese).

Histological changes in the thyroid gland were followed after injection of 0.5 to 1.25 $\mu\mu$C radioactive rainwater into pregnant mice. The rainwater was collected during a typhoon after weapons tests in the South Pacific. The peripheral area contained large follicles and the central region small ones, and in the periphery many follicles were irregularly fused together. These changes were similar to those seen after $^{45}Ca$ injection. The glandular epithelium was squamous or low cubic in form, the cytoplasm being stained lightly by hematoxylin. These changes were also similar to findings after $^{45}Ca$ injection, but pyknosis of nuclei was seen less frequently. When various other radioisotopes were injected, the epithelium was often partially deficient, but it was not defective. After $^{90}Sr$ and $^{32}P$ injections the development of cilia on the surface of the epithelium of irregularly formed follicles was noted. Similar to the results of $^{45}Ca$ injection, there was a smaller quantity of colloid in the central follicles, while in the peripheral follicles there was more. Most large follicles showed dense colloid, stained by Azan. No secretory vacuoles could be found in this colloid. Similar to the results with nonfallout radioisotopes, formation of new follicles in the parafollicular cells was rare in the case of radioactive rainwater. When radioisotopes, especially $^{32}P$, were injected, a large number of blood and lymphatic capillaries was found distributed in the connective tissue around the follicles. It is concluded that radioactive rainwater can induce histological changes in thyroid gland detectable even by the light microscope. (BBB)

**1828** EFFECT OF RADIATIONS IN VITRO ON BLOOD PLATELETS OF MAN AND THE RAT. Caen, J.; Sinakos, Z.; Cousin, Claire; Dupertuis, D.; Bourdon, R.; Bernard, Jean (Hopital Saint-Louis, Paris). Nouv. Rev. Franc. Hematol., 5: 780-3 (Sept.-Oct. 1965). (In French).

Changes in phosphohydrolase activity followed in fresh platelets and plasma after in vitro x irradiation with doses of 50, 200, and 800 R. After 50-R irradiation a decrease was noted in ATPase, ADPase, and neutral pyrophosphatase activities in platelets. In plasma only a moderate increase in neutral pyrophosphatase activity was noted. After 50-R irradiation, increases in ATP, ADP, and AMP were noted in platelets. In plasma, ATP increased while AMP decreased. It is known that ADP promotes aggregation of platelets while AMP inhibits it. These findings may thus explain the radioinduced aggregation of platelets. (TCO)

**1829** SOME EARLY EFFECTS OF X-IRRADIATION IN THE ULTRASTRUCTURE OF MOUSE LIVER CELLS. Kung, I-hung; Li, K'un; Szu, Ching-i; Ma, Chi-ch'ing; Ch'ien, Ch'ang-nien. (Inst. of Experimental Medicine, Peking). Sheng Wu Hua Hsueh Yu Sheng Wu Wu Li Hsueh Pao, 6: No. 1, 1-13(Feb. 1966). (In Chinese).

The ultrastructural changes of liver cells were observed from 5 minutes to 4 hours after x irradiation at dosage 100 R and 500 R given locally on the liver of white mice. The earliest change appeared half an hour after irradiation with 100 R and 10 minutes after irradiation with 500 R. The first change was the dilation of the endoplasmic reticulum followed by the focal diminution of density of the matrix of mitochondria, then intranuclear chromatin condensation, and vacuolization of endoplasmic reticulum and swelling of mitochondria. During the process of recovery, the nucleus recovered first, the mitochondria next, the endoplasmic reticulum and lysosome last. The significance of these findings is discussed. (C.H.)

**1830** MORPHOLOGIC CHANGES INDUCED IN THE LUNGS OF HAMSTERS AND RATS BY EXTERNAL RADIATION (X-RAYS). A STUDY IN EXPERIMENTAL CARCINOGENESIS. de Villiers, A. J.; Gross, Paul. Cancer, 19: 1399-1410(Oct. 1966).

Pulmonary cancers in hamsters and rats were induced with external x radiation. The induction and latent period of the pulmonary cancers observed in hamsters were reproducible. Invasive squamous cell carcinomata appeared in 5 (12%) of the 42 hamsters that died within the first 20 postirradiation weeks. In rats one squamous cell cancer and one adenocarcinoma were found in 32 animals that survived 12 to 24 months after irradiation. Pulmonary cancers were not found in hamsters later than $3\frac{1}{2}$ months postirradiation. This coincided with a predominance of mural stromal collagenization and the development of acellularity of alveolar walls. The method of producing lung cancer in hamsters and rats is suitable as an experimental model for the study of lung cancer because of the reproducibility and the control over experimental exposure factors. An average total dose of between 3,912 R and 4,094 R was delivered to the chest region of hamsters. Rats received an estimated 3,570 R. (auth)

**1831** CATECHOL-AMINE CONTENT OF THE CENTRAL NERVOUS SYSTEM AND ADRENALS OF RATS UNDER THE INFLUENCE OF NEUTRON AND X-RAY IRRADIATION. Satsukevich, V. B. (Inst. of Physiology, Academy of Sciences, BSSR). Dokl. Akad. Nauk BSSR, 10: 506-9(1966). (In Russian).

The role of the adrenal glands, specifically their medullary layer, in the reaction of the organism to radiation was studied. Male rats weighing 160 to 190 g were subjected to whole-body irradiation with intermediate-energy neutrons (dose above 13 rad) or with x rays at a dose of 40 R (dose power 21 R/min). On the 1st, 7th, 15th, and 30th days after irradiation, the catecholamine metabolism (adrenaline, norepinephrine, and oxidation products of adrenaline) was determined in the adrenals and cerebral cortex of the rats. The observed disruption of catechol-amine metabolism is evidence of the reaction of the medullary layer of the adrenals to radiation. Irradiation with both neutrons and x rays produced generally similar results in the animals. Changes in the catechol-amine content of the cerebral cortex of rats showed an unstable, phase character from the first to the thirtieth day after irradiation. Phase changes were noted in the amount of adrenaline and oxidation products of adrenaline after neutron irradiation, and in the amount of norepinephrine and oxidation products of adrenaline after x irradiation. A definite tendency towards increased adrenaline content in the cerebral cortex was observed after irradiation, and the increase was more pronounced for x irradiation than for neutron irradiation. A decrease in catechol-amine content was observed in rat adrenals after both types of irradiation. This decrease was also more pronounced during x irradiation. (ATD)

**1832** TISSUE RESPIRATION IN TRANSPLANTED TUMORS SUBJECTED TO THE EFFECT OF IRON ELECTROPHORESIS.

Yakimenko, L. V. pp 155-61 of Voprosy Eksperimental'noi Onkologii, Sbornik. Kiev, Zdorov'e, 1965. (In Russian).

Whole-body x irradiation of rats inhibited tissue respiration in transplanted carcinomas. A directly proportional relation was observed between the radiation dose and the inhibition of oxygen uptake by the tumors. Increased concentration of Fe ions in the tumor tissue, produced by electrophoresis, stimulated tissue respiration, as did an excessive accumulation of Fe ions in the body of the rats. The combination of irradiation and Fe electrophoresis resulted in considerably less inhibition of respiration of tumor tissue than was observed following treatment with x radiation alone. (C.H.)

**1833** EFFECTS OF 200 R WHOLE-BODY IRRADIATIONS ON THE GENITAL GLANDS OF IN UTERO IRRADIATED FEMALE WHITE MICE. Teichelmann, H. Berlin, Freie Univ., 1965. 28p. $2.00 Gmelin, AED-Diss. 65-377.

Thesis.

White mice were x irradiated with 200 R on the 15th day of gravidity. Vaginal smears of female mice irradiated as fetuses were taken. An increase of pathologically lengthened cycles was observed. (Dissertations Abstr.)

**1834** SWINE IN BIOMEDICAL RESEARCH. Proceedings of a Symposium at the Pacific Northwest Laboratory, Richland, Washington, July 19–22, 1965. Bustad, Leo K.; McClellan, Roger O. (eds.). Contract AT(45-1)-1830. Richland, Wash., Battelle-Northwest Lab., 1966. 846p. $16.50 cloth, $12.50 paperback. (CONF-650708).

Seventy-nine papers are included that discuss various aspects of the use of standard domestic swine and miniature swine in biological and medical research. Data are included on the anatomy, physiology, nutritional requirements, genetics, diseases and disease control, and the care and handling of swine used for research studies. The development of several strains of miniature swine is discussed. Results are included from studies on the acute mortality response and recovery from radiation injury in swine following whole-body exposure to x radiation; late effects observed in swine exposed to mixed neutron-$\gamma$ irradiation; the response of the skin of swine to x radiation; the comparative effects of $\beta$ irradiation on the skin of swine, sheep, and rabbits; and the toxic effects of ingested $^{90}Sr$, Pu, $^{144}Ce$, $^{147}Pm$, or Pu deposited on the skin of swine. Author and subject indexes are included. (1237 references.) (C.H.)

## Radiation Effects on Plants

**1835** (BNL-9434) EFFECTS OF IONIZING RADIATION AND FIRE ON GAYLUSSACIA BACCATA AND VACCINIUM VACILLANS. Brayton, R. D.; Woodwell, G. M. (Rutgers–The State Univ. of New Jersey, New Brunswick. Dept. of Botany. Brookhaven National Lab., Upton, N. Y.). [1965]. Contract AT(30-2)-Gen-16. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Fire and $\gamma$ radiation were shown to have parallel effects on the survival of natural populations of the shrubby plants, Gaylussacia and Vaccinium. Vaccinium is substantially more resistant to both thermal and $\gamma$ radiation. The differential sensitivity is due to differences in regenerative capacity; buds of Vaccinium are more resistant to damage, occur at greater depths in the soil, and are better protected from both $\gamma$ radiation and heat. This pattern of radiation and fire resistance lends further support to the general observation that in plants radiation resistance is related to ecological hardiness. (C.H.)

**1836** (BNL-10555) THE USE OF NEUTRONS AND OTHER IONIZING RADIATIONS IN THE BROOKHAVEN MUTATIONS PROGRAM. Briggs, Robert W. (Brookhaven National Lab., Upton, N. Y.). [1965]. Contract AT(30-2)-Gen-16. 5p. (CONF-660703-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Panel Meeting on the Use of Neutrons in Seed Irradiation, Vienna, Austria.

Irradiation facilities at Brookhaven National Laboratory for use in the exposure of plant material to neutrons, $\gamma$, or x radiation are described. A large number of irradiations were performed in 1955 and 1956 and, since plant breeding and mutation plant breeding are long-term ventures, new varieties induced are now being tested. The mutation program has also played a role in many fundamental research projects. Extensive data are available on the doses of radiation required to produce various levels of response on growing plants, and some data are available on irradiation response of seeds, and lists of varieties in the U. S. that were developed by mutation breeding is reported to be available. (C.H.)

**1837** (NYO-2587-21) MECHANISM OF ACTION OF X-IRRADIATION ON PLANTS. Final Report, May 15, 1960-August 31, 1966. Klein, Richard M. (New York Botanical Garden, N. Y.). Contract AT(30-1)-2587. 5p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The mechanism of action of x radiation on plants was investigated using an auxotrophic strain of Neurospora showing an absolute requirement for adenine and leaf discs cut from dark-grown bean plants as test systems. Conidia of Neurospora were isolated, washed, and exposed to 25 Krad dose of x radiation, visible light, infrared light, and/or selected chemical compounds, diluted, plated on selective media, and scored for survival, back mutation to adenine prototrophy, and colony morphology. Leaf discs were placed on filter paper moistened with buffer solution with or without the selected test compounds, irradiated, incubated, and the diameters were measured. The compounds used included oxidizing agents, reducing agents, mutagens, radiomimetic substances, and radioprotective compounds. Results showed that the deleterious effects of ionizing radiation are modulated by treatments which, by themselves, are not mutagenic, and that the mutagenic effects of ionizing radiation are partly due to the oxidizing, indirect effects of radiation. It was also shown that the action of phytochrome in photomorphogenesis in leaf discs can be mimicked or modulated by redox compounds. Possible reaction mechanisms involved are discussed. (C.H.)

**1838** EFFECT OF IONIZING RADIATION ON OXIDATION-REDUCTION PROCESSES OF SOME PLANTS. Tagizade, A. Kh.; Guseinov, S. G. Izv. Akad. Nauk Azerbaidzh. SSSR, Biol. Med. Nauk, No. 6, 91-8(1964). (In Russian).

Experiments were conducted on cotton, corn, and string beans under laboratory conditions in a greenhouse. Before the seeds were sown they were irradiated with doses of 500, 1000, 5000, and 10,000 R. The seeds germinated in pots containing 16 kg of soil into which was mixed 100 mg N and $P_2O_5$ to one kg of soil. The soil was maintained at 60% of total moisture capacity. At various stages of growth of the plants the activity of catalase, peroxidase, polyphenoloxidase, and ascorbic acid oxidase and the content of ascorbic acid and the iodine-reducing ability of the plant tissues were studied. The oxidative-reductive processes of the plants were markedly affected by irradiation. Doses of 500 and 1000 R increased the activity of catalase in beans, corn, and cotton. The activity of polyphenoloxidase in beans and peroxidase in cotton rose sharply under the influence of optimal doses of irradiation, while the iodine-reducing activity in all plants studied increased significantly. In corn and cotton the increase of reducing activity had a rhythmic character. The activity of ascorbic acid oxidase increased under the influence of 500, 1000, and 5000 R doses, leading to an increase in the content of ascorbic acid of the plants. The effect of radiation on oxidative-reductive ability of plants is connected with their effect on the internal biochemical processes. Radiation at moderate doses may ameliorate the quality of some vegetable products and increase the vital tone of the plant tissues. (BBB)

**1839** FURTHER STUDIES ON THE UV-INDUCED PHOTOREVERSIBLE AND NON-PHOTOREVERSIBLE MUTATION THROUGH THE ACTION SPECTRA IN YEAST CELLS. Ito, Takashi; Domon, Masaharu; Yamasaki, Terutoshi (Rikkyo Univ., Tokyo). Idengaku Zasshi, 41: 233-40(June 1966).

Ultraviolet-induced adenine-requiring mutation in yeast cells was investigated quantitatively at several wavelengths of monochromatic uv and at maximum photoreversion conditions in the hope of clarifying the mechanism of mutagenesis. In general uv-induced mutagenesis as well as mutation frequency following subsequent treatment with visible light increased almost linearly with the dose, irrespective of the wavelength used, except for some deviation in the shorter wavelengths. Photoreversible and non-photoreversible fractions of the induced mutations were determined by taking the ratios of the two slopes. Using a scattering factor of uv at the cell boundary, reliable absolute cross sections of the mutation were obtained for the several wavelengths. Implications of the findings were discussed with special reference to the relationship between mutation production and the inducible photochemical changes in DNA bases by uv. (H.G.D.)

**1840** COMPARATIVE ANALYSIS OF THE EFFECTS OF PHYSIOLOGICAL CONDITION OF SEEDS ON THE DEVELOPMENT OF CHROMOSOME MUTATIONS INDUCED BY CHEMICALLY ACTIVE SUBSTANCES AND BY IONIZING $\gamma$ RADIATION. Nuzhdin, N. I.; Samokhvalova, N. S. (Inst. of Genetics, Academy of Sciences, USSR). Dokl. Akad. Nauk SSSR, 166: 1217-20(Feb. 11, 1966). (In Russian).

Air-dried barley seeds from 1962 (state of forced rest) and 1963 (in state of reproductive rest) harvests were held 24 hr at 20 to 22°C and either $\gamma$ irradiated ($^{60}Co$) to 15 kR or treated with an aqueous solution of ethylene imine (EI), 0.02%; diethylamine salt of maleic acid hydrazide (DMH), 0.0002%; or N-nitroso-N-methyl urethane (NMU), 0.0002%. The seeds were sprouted 0 to 15 days later and the percentage of chromosome aberrations in the rootlets was determined. Half the 1963 seeds were de-shelled immediately after the irradiation or mutagen treatment before being

sprouted. Of the half that retained their shells, those in each group that did not sprout in 5 days were de-shelled and again subjected to sprouting conditions immediately after 10 days. The γ irradiated and EI-treated seeds in the organic rest state showed 20 to 25% aberrations, as did those artificially brought out of this state and sprouted after 10 days, but seeds in this last group which sprouted immediately showed half as many. Seeds treated with DMH showed values only about 25% of the above, while results of NMU treatment appeared to be independent of the state of the seeds. (TTT)

**1841** EXPERIMENTAL STUDIES OF THE EFFECTS OF FAST ELECTRONS IN VARIOUS IRRADIATION DEPTHS ON CHROMOSOME ABERRATIONS USING ROOT TIPS OF ALLIUM CEPA. Kolliopoulou. H. Goettingen, Ger., Univ., 1965. 42p. $2.00 Gmelin, AED-Diss. 65-357.

Thesis.

Radiation effects of 14.2-MeV electrons in depths corresponding to 100 and 300 relative depth dose were studied in Allium root tips. Mitosis frequency, phase distribution, and chromosome aberrations were investigated. A minimum of mitosis frequency occurred after 6 hr. Chromosome aberrations depended significantly on depth. (Dissertations Abstr.)

**1842** EFFECTS OF CHEMICAL AND PHYSICAL MUTAGENS ON FORAGE VETCH. II. COMPARISON OF CHROMOSOME ABERRATIONS PRODUCED BY ETHYL METHANE SULFONATE, ETHYLENE IMINE AND X RAYS. Magri-Allegra, G.; Zannone, L. (Istituto Nazionale di Genetica per la Cerealicoltura N. Strampelli, Rome). 12p. (CONF-551-6). ORAU.

From Technical Meeting on the Use of Induced Mutations in Plant Breeding Programs, Rome, May-June 1964.

The evaluation of mutagenic effects of chemical and physical (x rays) treatment applied to dormant seeds of different species of vetch carried out on the basis of induction of chromosome breakages has evidenced higher efficiency of x rays than that of chemicals. Of the two chemicals tested ethylene imine (EI) produces a relatively higher cytological damage than ethyl methane sulfonate (EMS). As for types within the species, no difference was evidenced among the three types of sativa; slight difference was found between the two types of villosa. As for the species, there was no clear difference between sativa and villosa, but between those two and ervilia the mutagenic effect is much different. When chromosome breakage effect was compared with growth reduction effect a difference was evidenced between two strains of villosa, at least for EMS and x rays. The difference in frequency distributions of the various types of chromosome breaks is statistically as highly significant for treatments as for species. Chemicals gave relatively higher frequencies of bridges than x rays. The chromosome lagging effect followed, for intensity and trend, that of induction of chromosome breakage, both as regards the comparison among the treatments and the relations of the species. Generally speaking the effects of chemical and physical mutagens, evaluated on the basis of $M_1$ seedling growth reduction as well as on the frequency of lagging chromosomes seems to indicate a peculiar trend for species and in some cases for types within species. (auth)

## Radiation Effects on Microorganisms

**1843** (AD-640596) EFFECT OF X-RADIATION ON THE GROWTH AND DIVISION PROCESS OF TETRAHYMENA PYRIFORMIS. Schmid, P. (Naval Radiological Defense Lab., San Francisco, Calif.). Sept. 12, 1966. 16p. (USNRDL-TR-1070). CFSTI $1.00 cy, $0.50 mn.

Shortly after the beginning of x irradiation a division block was imposed on exponentially replicating cells of Tetrahymena and thereafter no cell division was observed for several hours. However, following x irradiation Tetrahymena grew exponentially and increased in volume. The volume distribution of control and x irradiated culture was lognormal. Furthermore, small cells originating from cells at the beginning of the division cycle grew at the same rate as large cells originating from cells which were close to division. This indicates that cell growth is independent of the cell division cycle to a significant extent. X irradiation caused a temporary inhibition of the incorporation of tritiated thymidine into the DNA of cells, but DNA synthesis was resumed during irradiation, followed exponential kinetics even after x irradiation was discontinued and stopped shortly before synchronous division. Thus, some biochemical adaptation of DNA synthetic mechanisms takes place during irradiation. (auth)

**1844** (COO-1432-2) [EFFECTS OF UV AND ACTINOMYCIN ON MITOSIS IN PHYSARUM POLYCEPHALUM; PREPARATION AND UPTAKE OF RNA BY PLASMODIA OF P. POLYCEPHALUM]. Technical Progress Report, September 1, 1965–August 30, 1966. Guttes, E. W.; Devi, Vimala R. (Loyola Univ., Chicago, Ill.). Sept. 15, 1966. Contract AT(11-1)-1432. 47p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Progress is reported on studies on the effects of ultraviolet radiation and actinomycin on mitosis in Physarum. A considerable delay of mitosis resulted from the addition of 50 μg/cc of actinomycin to the medium and even 20 μg/cc produced a significant delay. Delay in mitosis was observed following exposure of surface plasmodia to uv radiation. Irradiation during an early stage of mitosis caused reversal to interphase and mitosis did not occur until approximately 11 hr later. In most cases when mitosis immediately following irradiation was delayed the mitotic cycle during the next 5 cell cycles was considerably shorter than that in unirradiated multinucleated plasmodia. The DNA ratios were higher in the first post-irradiation prophase of irradiated plasmodia than in corresponding pre-prophases of the controls suggesting that a uv-sensitive event occurs just prior to and during the early stages of mitosis, including prophase. After uv interference with this event the nuclei reverted to interphase and it is postulated the event might involve RNA synthesis as suggested by the incorporation of $^{3}H$-uridine, as demonstrated by scintillation counting. (C.H.)

**1845** (NYO-3511-2) INHIBITION OF THE SYNTHESIS OF MACROMOLECULES BY ULTRAVIOLET RADIATIONS. Final Report, February 1, 1965–July 31, 1966. Swenson, Paul A. (Massachusetts Univ., Amherst). Sept. 15, 1966. Contract AT(30-1)-3511. 9p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Progress is reported on studies on the effects of uv radiation on the synthesis of macromolecules by radiosensitive and radioresistant strains of Escherichia coli. Data are included from studies on the effects of uv radiation on the β-galactosidase-forming ability of the bacteria at various temperatures from 5 to 37°C. The radiosensitivity of tryptophanase and d-serine deaminase systems in the two strains was also studied. Strain differences in enzyme-forming ability, dark repair, response to photoactivating light, respiration, and RNA and protein synthesis were found in the uv-irradiated bacteria. (C.H.)

**1846** (ORO-2139-9) NUCLEIC ACID FORMATION AND GENETIC EVENTS IN BACTERIA. Annual Progress Report, 1966. Doudney, C. O. (Anderson (M. D.) Hospital and Tumor Inst., Univ. of Texas, Houston). July 1966. Contract AT(40-1)-2139. 11p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Progress is reported on studies on the effects of uv radiation on genetic events and nucleic acid synthesis in Escherichia coli. Data are included from studies on the photoreversal of uv damage to DNA synthesis; the effects of uv radiation on RNA and protein synthesis and the nature of the molecular mechanism by which RNA synthesis effects restoration of the uv-damaged DNA synthetic system; the requirement for RNA formation in DNA replication; the effects of acriflavine on RNA accumulation in uv-damaged bacteria; and mechanisms for uv-induced mutation. (C.H.)

**1847** (ORO-2139-10) NUCLEIC ACID FORMATION AND GENETIC EVENTS IN BACTERIA. Three Year Comprehensive Report. Doudney, C. O. (Anderson (M. D.) Hospital and Tumor Inst., Univ. of Texas, Houston). July 1966. Contract AT(40-1)-2139. 17p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Results are summarized from studies on the effects of uv on Escherichia coli. The data indicate that exposure to low doses of uv results in a recoverable block to DNA synthesis and a relation exists between the dose and duration of delay in DNA synthesis. Above a certain critical dose little further delay in DNA synthesis was observed and the rate of DNA synthesis decreased with increasing dose above this level. The replication of DNA was followed in bacteria grown for several generations on $^{15}N$-labeled medium and transferred to $^{14}N$-labeled medium immediately after uv exposure. The kinetic aspects of DNA synthesis after uv exposure and the effects of acriflavine, caffeine, and certain dyes (crystal violet and methyl green) on the synthesis of DNA, RNA, and protein, survival, and mutation induction in uv-exposed bacteria were studied and results indicate that these agents exert some action on uv-exposed cells that result in increased mutation frequency and lethality, as well as in blockage of DNA, RNA, and protein synthesis, while having little effect on non-uv-exposed cells. It was concluded that most of the genetic and physiological effects of uv are related to the induction of the thymine dimer in DNA. (C.H.)

**1848** INACTIVATION BY IRRADIATION OF SPORES OF BACILLUS THURINGIENSIS VAR. THURINGIENSIS. Cantwell, George E.; Franklin, B. A. (Dept. of Agriculture, Beltsville, Md.). J. Invert. Pathol., 8: 256-8(June 1966).

Effects of $^{60}Co$ γ radiation, uv radiation, and sunlight on spores of this bacteria were studied. Because of the difficulty of recovering spores from leaves, all spores were irradiated while they were suspended on Millipore filters or glass slides. Radiation by the $^{60}Co$ source (400 R/min) was very time-consuming since 400 min-

utes were needed to inactivate 97% of the spores. The short-wave uv lamp, however, inactivated 99.997% in 10 min. The results of lesser exposures are shown. The data indicate that nearly 50% of the spores were inactivated by exposure for 30 min to the sun and that over 80% were inactivated in 1 hr. These tests may not approximate normal field application, but they do show that a very high percentage of unprotected spores may be inactivated in a relatively short time in the field. A factor such as this could explain some of the discrepancies between lab tests and field tests with B. thuringiensis. The possibility of using certain carriers that would afford the spore much protection should be investigated. (BBB)

**1849** ACRIDINE ORANGE-SENSITIZED PHOTOINACTIVATION OF THE CAPACITY OF ESCHERICHIA COLI FOR BACTERIOPHAGE T4. Cramer, W. A. (Univ. of California, San Diego, La Jolla); Uretz, R. B. Virology, 28: 142-9(Jan. 1966).

E. coli has the capacity to support the growth of viable T-even bacteriophage exposed to amounts of uv, $^{32}P$, and x rays many times greater than doses sufficient to destroy colony-forming ability. However, under conditions where white light or its near-uv component inactivates the colony-forming ability of E. coli, the capacity of these cells to grow phage T2 is inactivated even faster than the colony-forming ability. Under conditions where visible light ($\lambda > 410$ mμ) alone causes no inactivation, exposure of E. coli to visible light in the presence of the dye acridine orange and oxygen causes inactivation and mutation. Under these conditions it was found that the inactivation of the colony-forming ability and of the capacity for phage T4 of E. coli B/r proceed at about the same rate. There is no inactivation of this capacity by visible light alone ($\lambda > 410$ mμ) or dye alone. Experiments with KCN-blocked phage-E. coli complexes suggest: (1) T4 phage do not inject in the presence of 0.01M KCN; (2) acridine orange-visible light inactivation of T4 capacity is due to damage which prevents injection and/or early function; (3) the sensitivity of the phage itself decreases greatly at the time of or shortly after injection, a phenomenon unique to Luria-Latarjet experiments. These experiments on inactivation of T4 capacity imply that some component of the cell besides DNA is significantly damaged by acridine orange-absorbed light energy. It is suggested that this other component is some part of the cell membrane. The dye might attach to membrane-bound RNA and ATP, or perhaps to any site of negative charge on the membrane; or light energy absorbed by the dye complexed to membrane-bound DNA might lead to inactivation of capacity as well as lethality and mutation. (BBB)

**1850** THE ACTION OF ULTRAVIOLET RADIATIONS ON THE ANTAGONIC SYSTEM STAPHYLOCOCCUS 31A-BACILLUS MEGATERIUM 207. Moraru, Ion; Antohi, Stefan (Medico-Legale Inst. Mina Minovici, Bucharest). Biochem. Biophys. Res. Commun., 24: 916-22(Sept. 22, 1966).

Studies were made on strains of Staphylococcus and Bacillus megaterium exposed to ultraviolet irradiation as pure cultures and then mixed with unirradiated cells or exposed as mixtures of the two organisms. It was concluded that lysis of bacilli in a Staphylococcus and B. megaterium mixture cannot be ascribed to a bacteriocin; that a genetic material is transferred through the fusion bridges from the staphylococci to the bacilli; that an associated biosynthesis of the genetic material in staphylococcal cells is necessary for the transfer; and that the lysis of bacilli is the consequence of a lethal heterozygosis that occurs, although no lytic factor is released in the medium. (C.H.)

**1851** ULTRAVIOLET INDUCED MUTATION OF GEOTRICHUM CANDIDUM. Wu, Yang-yong; Hsu, Cheng-ji; Qi, Yi-peng; Chen, Ke-ming; Lui, Da-jiang. Acta Microbiol. Sinica, 11: 202-9 (May 1965). (In Japanese).

The influence of different doses of ultraviolet irradiation on the survival rate and the morphological mutation rate was studied in Geotrichum. It was found that the survival rate was decreased by the increasing doses of irradiation, but the mutation rate was increased at first, followed with a decrease, and then increased again, forming a double peaked curve. Irradiation of spore suspension at a distance of 25 cm for 5 minutes resulted in the maximum mutagenic effect. Six hundred and sixty morphological colonies were obtained from 10,761 colonies studied. Three hundred and sixty colonies of the 660 mutant colonies varied obviously, and were able to be divided into 6 types. Most of these types were obtained with 5 minutes irradiation, but the least, with 1 minute irradiation. After a single treatment of Geotrichum with uv irradiation, the protein and fat contents of the mycelium were increased. After a double treatment, the protein content was further increased but the fat content was decreased. A contrary result was obtained with a triple treatment. (auth)

**1852** EFFECTS OF HIGH-ENERGY IONIZING RADIATIONS ON THE TUBERCLE BACILLUS. (1ST RESEARCH SERIES). Stuhl, L.; Benda, R.; Frey, N. (Hopital Beaujon, Paris). Bull. Mem. Soc. Med. Hop. Paris, 115: 927-33(June 19, 1964). (In French).

The effects of 200-kv x rays and $^{60}Co$ γ rays on various types of tubercle bacilli were compared in vitro and in vivo. The x ray doses varied from 3000 to 30,000 R and the γ-ray doses 30,000 to 140,000 R. At doses above 30,000 R, the H37Rv strain of Mycobacterium tuberculosis developed resistance to isoniazid. It became more marked as the dose reached 80,000 R. At doses above 80,000 R, multiplication of the bacteria was decreased and at 140,000 R it was completely inhibited. The virulence of strain H37Rv was diminished after exposure to two doses of 80,000 R. In a strain that was isoniazid-resistant before irradiation, doses of 80,000 and 140,000 decreased this resistance in a way that paralleled the drop in virulence. In addition to the above-described in vitro studies, experiments were also conducted in guinea pigs. Animals injected with live H37Rv bacilli died after an average of 39 days compared with 100 days in animals inoculated with 80,000-R irradiated bacilli. Treatment of the guinea pigs with isoniazid did not prolong survival. (BBB)

## Radiosterilization and Radiopreservation

**1853** NEW BACTERIOLOGICAL PROBLEMS IN NEW SEMI-PRESERVED FOODS. Ingram, M. (Low Temperature Research Station, Cambridge, Eng.). Ann. Inst. Pasteur Lille, 15: 3-9(1964).

Examples are given to show that when semipreserved foods are produced by irradiation and other processes which do not kill or inhibit all microorganisms present, the mere suppression of the normal spoilage flora may increase the risks from food-poisoning pathogens. Irradiation experiments on the growth of staphylococci on bacon are described. Staphylococci are of interest because they are capable of growing on cured foods of composition which inhibits clostridia or salmonellas. Staphylococci inoculated onto nonirradiated bacon carrying its normal bacterial flora did not grow much, but staphylococci on radiation-sterilized (5 Mrad) bacon grew rapidly and extensively, while those introduced into partially radio-sterilized (1 Mrad) bacon grew at an intermediate rate. There were independent indications that enterotoxin formation would have been possible in these circumstances, and that the toxin would survive the usual cooking. (TCO)

**1854** STERILIZING WITH IONIZING RADIATION. Clouston, J. G.; Sangster, D. F. (Australian Atomic Energy Commission, Lucas Heights, New South Wales). Austral. J. Pharm., 45: Suppl. 18, 548-51(June 30, 1964).

Use of radiation to sterilize food and medical supplies is reviewed, with emphasis on the doses required, chemical effects, and technology of the process. If radiation processing of food must be equal in public health safety to thermal processing and for those foods where Clostridium botulinum is a hazard, an inactivation factor of $10^{12}$ would be necessary. However, in the sterilization of medical equipment by ionizing radiation, a standard inactivation factor may not exist but from a study of the degree of sterility achieved by thermal methods a factor of $10^{7}$ might be necessary for a radiation-resistant standard organism. Examples are cited to indicate that this standard is being met, when radiation is being used for medical sterilization. Some considerations in determining the best conditions for killing organisms are temperature, moisture, spore or vegetative form, and the presence of protective or sensitizing agents, in particular oxygen. Doses in the range 2.5 to 4.5 Mrad seem to give adequate security. Although the chemical and physical changes produced in irradiated materials are, for many applications negligible, they may affect the biological activity of medicinal chemicals. This aspect is discussed. Substances in solution, particularly aqueous solution, are generally more susceptible to chemical change than dry substances. Not enough is known about the effects of radiation on organic substances in general to predict the effects in a particular case and so each compound or preparation has to be examined empirically. It is concluded that industrial processing with radiation is at present limited, but it may be more widely used in the future for the sterilization of pharmaceutical preparations. (TCO)

**1855** ON RADIATION-INDUCED SPROUT INHIBITION AND THE SIDE-EFFECTS. Skou, J. P. (Danish Atomic Energy Commission Research Establishment, Risoe). Kerntechnik, 8: 510-13 (Nov. 1966).

The problem of sprout inhibition in potatoes, carrots, and onions was studied. The use of ionizing radiation as a sprout inhibitor was investigated and its side effects evaluated. Radiation sources; radiation effects on germination and sprouting; physiological changes

in the irradiated products; radiation effects on storage losses; nutritive and culinary value of the irradiated products; wholesomeness; and use of irradiation for prolongation of storage life are discussed. (D.H.M.)

**1856** IRRADIATION FACILITIES. Food Irradiat., 6: No. 4, A1-54(Apr.-June 1966).

Irradiation facilities operative in 1966 in Belgium, Canada, Denmark, France, Germany, Japan, The Netherlands, Spain, United Kingdom, and the United States are described briefly. Drawings and photographs of many of the facilities are given. Data on the source, purpose, radiation doses produced for various applications, and dosimetry methods used are included. The facilities are primarily for food irradiation but some are also used for the irradiation of industrial materials. Radiation sources used include $^{60}$Co $\gamma$ sources, irradiated reactor fuel elements, and electron linear accelerators. Applications of radiation in food processing in the USSR and Thailand are discussed briefly. (C.H.)

**1857** EFFECTS OF $^{60}$Co $\gamma$ RAYS ON NATTO. Urakami, C.; Sakamoto, R.; Takada, A.; Tanaka, H.; Furuhashi, N.; Uemura, T. (Osaka City Univ.). Radioisotopes (Tokyo), 15: 228-33(Sept. 1966). (In Japanese).

Studies were made on effects of $^{60}$Co $\gamma$ rays, at dose levels of 0.63, 1.3, and $4.5 \times 10^5$ rad under ice-cooling, on Natto sealed in film in relation to its appearance, flavor, carbonyl, and TBA values, contents of free sugars, free amino acids, and the classes of phospholipids. No off-flavor appeared up to $1.3 \times 10^5$ rad but a pungent odor was detected at $4.5 \times 10^5$ rad. Such observations were reflected on the carbonyl and TBA values; no increase in the values up to $1.3 \times 10^5$ rad but a distinct increase was noted at $4.5 \times 10^5$ rad. The content of free sugars remained unchanged at all the dose levels. A total amount of free amino acids remained unchanged up to $1.3 \times 10^5$ rad but some increase at $4.5 \times 10^5$ rad. Amino acid analysis showed a considerable increase in amounts of methionine, leucine, tyrosine, arginine, and phenylalanine at the highest dose level but a decrease in amounts of lysine and histidine. Irradiation did not alter the classes of phospholipids present in the beans but caused a significant change in their fatty acid composition. Some alterations occurred in the classes of phospholipids of mucilage. The compounds appeared to be polyphospatidic acid and phosphatidic acid, which were absent in the control sample, but were detected in the irradiated sample. (auth)

**1858** EFFECT OF PACKAGING ON THE MAJOR MICROBIAL FLORA OF IRRADIATED HADDOCK. Sinskey, T. J. (Massachusetts Inst. of Tech., Cambridge); Pablo, I. S.; Silverman, G. J.; Ronsivalli, L. 12p. (CONF-660539-4). ORAU. Gmelin, AED-CONF-66-114-4.

From American Society for Microbiology, 66th Annual Meeting, Los Angeles.

Studies on fish indicated that $\gamma$ radiation at 150 krad drastically reduced the number of gram negative microorganisms associated with fish spoilage, leaving large numbers of the more radioresistant gram positive bacteria and fungi. Subsequent growth of the radiation survivors was found to be a function of storage temperature. Samples of irradiated haddock fillets were packaged in cans without hermetic sealing but covered with aluminum foil to allow free exchange of air, sealed with a limited air headspace, or vacuum packed and stored at 30°C for three weeks. The results of bacteriological studies showed that the microbial spectrum was altered by the presence or absence of air during refrigerated storage. After three weeks in storage, all of the irradiated samples were judged by odor and appearance to be of an acceptable quality. The dominant flora associated with each packaging method are listed. (C.H.)

# METALS, CERAMICS, AND OTHER MATERIALS

## Metals and Alloys

*Refer also to abstracts 1312 and 2827.*

### Corrosion and Erosion

*Refer also to abstracts 1392 and 2864.*

**1859** (AE-245) INTERCRYSTALLINE STRESS CORROSION CRACKING OF INCONEL 600 INSPECTION TUBES IN THE ÅGESTA REACTOR. Groenwall, B.; Ljungberg, L.; Huebner, W.; Stuart, W. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Aug. 1966. 25p. Dep. mn.

Intercrystalline stress corrosion cracking was observed in three so-called inspection tubes of Inconel 600 in the Ågesta reactor. The cracks developed on the outside surface of the tubes, which were exposed to 217°C light water containing normally 1 to 4 ppM LiOH or KOH and small amounts of $O_2$ and chloride. These elements may have enriched in the crevices at which most of the cracking occurred. Other factors which are thought to have contributed to the cracking are tensile stresses of the order of the 0.2% offset yield strength, built up during shop welding, and a relatively high C content of the alloy (0.08%) giving rise to heavy precipitation of carbides, intergranularly as well as interior of the grains. The tube material had an unusually high yield of strength. Irradiation and surface contamination were found to be of no importance. The observations seem to agree with previously published observations of intercrystalline stress corrosion cracking in Inconel 600. Attempts to reproduce the failure in the laboratory have not yet yielded cracks. (auth)

**1860** (COO-1319-42) A STUDY OF THE MECHANISM OF STRESS CORROSION CRACKING IN THE IRON–NICKEL–CHROMIUM ALLOY SYSTEM. Quarterly Report, March 17, 1966–June 16, 1966. Staehle, R. W. (Ohio State Univ. Research Foundation, Columbus). Aug. 30, 1966. Contract AT(11-1)-1319. 56p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Stress corrosion cracking experiments are reported in dilute chloride environments at 500°F and in boiling $MgCl_2$ environments. Data are reported in terms of % unbroken vs time. Studies on effect of surface preparation are reported. Results of these studies show that various surface preparations greatly affect mean cracking times and can cause significant differences in data scatter. A study of the effect of alloy composition on annealing twin frequency was completed and final results show generally that increasing the Ni and Cr increases the frequency of annealing twins. Results are reported from a study of tensile properties as a function of temperature and alloy composition. A potentiokinetic polarization study was completed for the ternary Fe–Cr–Ni alloy system and results are summarized graphically. Figures presenting concepts in the theory of stress corrosion cracking are included. (auth)

**1861** (EURAEC-1716) THE INFLUENCE OF NITROGEN ADDITIONS ON PHASE RELATIONS IN AISI TYPE 304. Summary Report 438-A. (Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering). Aug. 1966. Contract AT(40-1)-3208. 32p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

An investigation of the phase relations in AISI type 304 to which $N_2$ was added at 538°C was completed. The solid solubility limit of $N_2$ in type 304 and the free energy of solution have been established at 538°C. At $N_2$ concentrations greater than the solubility limit, nitrides were found and identified. (auth)

**1862** (GEAP-4436) SODIUM MASS TRANSFER. IX. THE EFFECT OF CARBON AND CARBONATE ADDITIONS IN A SODIUM TEST LOOP. Lockhart, R. W. (comp.) (General Electric Co., San Jose, Calif. Advanced Products Operation). May 1966. Contract AT(04-3)-189. 48p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The penetration of C into type 316 stainless steel exposed to circulating Na and associated impurities in the liquid metal and cover gas were measured. Carburized C steel was demonstrated to be an effective C source with system temperatures as low as 800°F. The addition of $Na_2CO_3$ to the Na produced elevated $O_2$ levels but the evidence of C transfer was negligible. C penetration rates were measured by machining thin layers of metal from cylindrical samples and analyzing the turnings for C. Reasonable diffusion rates in the steel at 800 to 1000°F were obtained. (auth)

**1863** (NP-16274) COMPREHENSIVE CAVITATION DAMAGE DATA FOR WATER AND VARIOUS LIQUID METALS INCLUDING CORRELATIONS WITH MATERIAL AND FLUID PROPERTIES. Technical Report No. 6. Garcia, Ramon (Michigan Univ., Ann Arbor. Lab. for Fluid Flow and Heat Transport Phenomena). Aug. 1966. 430p.

Thesis.

Cavitation-erosion phenomena were studied by determining cavitation resistance of many useful materials, correlating cavitation damage and fluid properties, and relating damage in a flowing venturi device to damage in the accelerated vibratory facility. A critical high-temperature ultrasonic device was developed for the vibratory facility. Studies in the vibratory facility showed that Ta-base alloys were the most cavitation resistant. Computer correlations of cavitation damage data with applicable mechanical and fluid properties indicate that there is no single mechanical property which can be used to correlate the damage with good precision. A simple comprehensive correlating equation involving ultimate resilience of the material and fluid density is relatively satisfactory. Direct comparison of flowing system (venturi) and vibratory results shows that the rankings of materials for cavitation damage are quite similar but the relative ratios between different materials are much greater in the venturi facility. This indicates the feasibility of the accelerated vibratory results in interpreting cavitation experiments in flowing systems. (F.S.)

**1864** (ORNL-3994, pp 88-94) ELECTROCHEMICAL KINETICS AND ITS APPLICATION TO CORROSION. (Oak Ridge National Lab., Tenn.).

Further studies on the inhibition of corrosion of iron and steel showed that inorganic substances of the general formula $XO_4^{n-}$ exert a noncathodic effect that greatly facilities the passivation process. A mechanism is proposed, which accounts for the complex electrochemical behavior of iron in the presence of adsorbed anionic inhibitors. Studies with a rotating disk electrode assembly on the dissolution of Zr in HF–HCl and HF–$HNO_3$ mixtures showed that at potentials below the pitting potential in chloride media the rates of dissolution in the two solutions are identical. This result suggests that neither $Cl^-$ nor $NO_3^-$ ions exert a specific effect on the dissolution of the passive oxide layer by HF. Other experiments in HF–$H_3PO_4$ solutions disclosed a reduction in dissolution rate by several orders of magnitude; $PO_4^{3-}$ ion inhibited the dissolution reaction by HF in a manner similar to the $SO_4^{2-}$ ion. The diffusion coefficient of HF in certain solutions of interest was determined by the open-end capillary method. The rate of the anodic dissolution reaction of aluminum in alkaline NaCl solutions was measured as a function of pH, electrode potential, and time by use of a rotating disk electrode assembly. Observed changes in the rate of the dissolution reaction with time may be interpreted in terms of the kinetics of formation and dissolution of a porous aluminum oxide layer on the metal surface. This hypothesis was verified by electron micrographs of the oxide layers. Experiments were initiated on electrochemical aspects of the formation and growth of pits on titanium in chloride solutions. No significant effect of solution velocity on the initiation and growth processes was observed up to approx 3500 rpm. Breakdown potentials observed on application of constant current were found to depend to some extent on the initial thickness of the passive oxide layer, although the final pitting potential was relatively unaffected. Addition of sulfate ions increased the breakdown potentials but hardly affected the pitting potential. Growth kinetics of single pits were investigated potentiostatically. Polarization curves of Ti and some of its alloys were measured in chloride solutions at temperatures up to 200°C by use of a Ti loop facility equipped for electrochemical studies. In the presence of a sufficient quantity of chloride ions, Ti alloys exhibited a pitting potential, which in some cases is low enough to allow pitting attack to proceed spontaneously. Increase of temperature profoundly affects the value of the pitting potential; plots of pitting potential as a function of temperature are reproducible and show clearly which alloys are superior in tendency towards pitting attack. Electrochemical aspects of the corrosion of types 5454 and 6061 Al alloys were studied in 1M NaCl at 150°C in Ti loop facilities. Changes in the polarization curves of anodic and cathodic processes occurring at the Al-electrolyte interface with pH provided a kinetic explanation for the existence of a minimum corrosion rate in chloride media. An enhanced rate of the cathodic process on the 6061 alloy accounts for its greater corrosion rate at any pH and for its susceptibility to pitting attack; this catalysis may be attributable to the Cu content of the 6061 alloy. (auth)

**1865** OXIDATION AND ABLATION CHARACTERISTICS OF TANTALUM IN A HYPERTHERMAL ENVIRONMENT. Marshall, Billy W. (Sandia Corp., Albuquerque, N. Mex.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 4: 1899-1905 (Nov. 1966).

The characteristics of Ta ablation in $O_2-N_2$ mixtures were investigated in a hyperthermal arc tunnel facility. The Ta melted and was swept away by the high-velocity gas stream at temperatures near and in excess of 1800°C, which is much lower than the melting temperature of Ta 2980°C. This phenomenon is attributed to the reaction of Ta with $O_2$ in the gas and, in the test conditions, the ablation rate was limited by $O_2$ diffusion through the boundary layer. Reacted material from near the leading surface was identified by x-ray diffraction analyses as alpha $Ta_2O_5$ and Ta metal. Nitrides or intermediate oxides were not found. Neutron activation analyses established an approximate over-all average composition corresponding to that of "TaO." Calculation of reaction rates based on a TaO composition gives good agreement with the experimental data, whereas calculations based on a $Ta_2O_5$ formation are not in agreement with these data. (auth)

**1866** RAPID OXIDATION-FREE HEATING OF METALS FOR ROLLING. Grdina, Yu. V.; Tarasko, D. I.; Dadochkin, N. V.; Gordin, O. V. (Siberian Metallurgical Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Chern. Met., No. 2, 119-21(1966). (In Russian).

In a search for an effective and inexpensive method of heating steels and refractory metals for forging, rolling, and extrusion, molten glass has been tested as a heating medium. Specimens of steels 60S2, 45G, St5, and molybdenum, tungsten, and niobium were heated up to 1100 to 1350°C in molten glass (71.88% $SiO_2$, 1.11% $Al_2O_3$, 1.5% $Fe_2O_3$, 7.32% CaO, 2.27% MgO, 14.15% $K_2O$ + $Na_2O$) for 5 min to 3 hr. No sign of oxidation was observed on any specimen. On the other hand, 60S2 steel conventionally heated to 1150°C was extensively oxidized after holding 20 min. This type of steel, badly affected by decarbonization in conventional heating, showed no sign of decarbonization when heated in molten glass. The molten glass forms a compact, gas-tight film on the metal surface which also protects the metal against oxidation outside the bath, such as in hot rolling with 5 to 20% reduction, in forging, or in extrusion. In rapidly cooled carbon steels, the protective film cracks and a slight oxidation (temper colors) is observed. Refractory metals, however, are not oxidized at the temperatures at which the temper colors are formed. (ATD)

**1867** CORROSION OF ZIRCALOY-2 BY HYDROGEN PEROXIDE AT ELEVATED TEMPERATURE. Davis, R. J.; Mauney, T. H.; Hart, J. R. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. J. Electrochem. Soc., 113: 1222-3(Nov. 1966). (ORNL-P-2320).

Specimens of Zircaloy-2 were exposed to $10^{-5}$M $H_2O_2$ at 280°C for 297 hr. Results indicated that corrosion of Zircaloy-2 by oxygenated water is not enhanced by continuous feeding of hydrogen peroxide at a concentration of $10^{-5}$M, the estimated concentration during irradiation by a fast neutron flux of $10^{13}$ n/cm$^2$/sec. This flux is known to result in a corrosion rate of about 70 μg/cm$^2$/day. From the observed rates of 7–8 μg/cm$^2$/day, it follows that hydrogen peroxide in solution is not responsible for the corrosion acceleration which results from irradiation by fast neutrons. (J.G.B.)

**1868** CORROSION BY LIQUID METALS AND FUSED SALTS. Simons, E. M. Reactor Mater., 9: 107-10 (Summer 1966).

Studies on the corrosion of refractory metals and alloys by liquid metals and fused salts are reviewed. (H.D.R.)

**1869** EFFECT OF ANODIC FILMS ON THE GASEOUS OXIDATION OF TANTALUM. Pawel, R. E.; Campbell, J. J. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. J. Electrochem. Soc., 113: 1204-9(Nov. 1966). (ORNL-P-2329).

The influence of anodic films up to 3000 Å thick on the subsequent high-temperature oxidation characteristics of Ta was studied. At a given temperature, the anodic films decreased the gross $O_2$ consumption rate to an extent dependent on their thickness and also delayed the onset of the breakaway increase in the oxidation rate common to this metal. The result that very thin anodic films pass comparatively large quantities of $O_2$ to the metal while postponing the appearance of the crystalline oxide phases permitted some $O_2$ solution effects during the early stages of oxidation to be observed. (auth)

**1870** MECHANISM OF STRESS CORROSION IN MATERIALS FOR NUCLEAR APPLICATIONS. Thomas, K. C.; Allio, R. J. (Westinghouse Electric Corp., Pittsburgh). 35p. (CONF-660627-660627-8). ORAU, Gmelin, AED-CONF-66-198-16.

From American Society for Testing and Materials, 69th Annual Meeting, Atlantic City.

The types of stress corrosion failure observed in austenitic stainless steel are described. Failures attributed to transcrystalline defects in austenitic stainless steel nuclear plant components are documented. In addition, the stress-corrosion failure of a Zr-base alloy pressure tubes in the presence of $I_2$ is described. The theories of stress-corrosion are critically reviewed and their limitations outlined. An alternate theory is proposed to explain transcrystalline failure of austenitic stainless steels in chloride environment. It is shown that this theory can adequately explain some of the phenomenon not accounted for by previous theories. A model is also proposed for the stress-corrosion failure of Zr-base alloys in chloride solutions, which would also be applicable to other halide solutions. (auth)

## *Preparation and Fabrication*

*Refer also to abstracts 1917 and 2871.*

**1871** (AECL-2624) STRESS REORIENTATION OF HYDRIDES IN COLD-WORKED ZIRCONIUM-2.5 PERCENT NIOBIUM PRESSURE TUBES. Parry, G. W. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Aug. 1966. 22p. Dep. mn. AECL $1.00.

The susceptibility of cold drawn Zr-2.5% Nb pressure tubes to reorientation of hydride precipitates during cooling under an applied stress was investigated. It is concluded that little orientation occurs at stresses up to 35,000 psi, and when it occurs its effect on tensile properties is small. The tests tend to confirm the conclusions of previous investigators, that a high concentration of basal poles parallel to the applied stress is necessary for reorientation of the hydrides. (auth)

**1872** (AERE-M-1801) WELDING TECHNIQUES FOR SMALL CAPSULES. Ewart, F. T.; Carney, R. A. (Atomic Energy Research Establishment, Harwell (England)). Sept. 1966. 6p. Dep. mn. BIS $0.50. HMSO 2s. 6d.

A technique is described for producing high-integrity welds, in small closely defined areas on irradiation capsules. The method was originally developed for stainless steel; it has now been extended to include Mo alloys and W. (auth)

**1873** (SC-DR-66-469) SOLDERING TO GOLD PLATE. Sasmor, D. J.; Greulich, F.; Romero, H.; Mead, K. E. (Sandia Corp., Albuquerque, N. Mex.). Sept. 1966. Contract AT(29-1)-789. 30p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The solution and reaction of Au in 60/40 (Sn/Pb) solder was studied utilizing metallographic techniques and the electron microprobe. The results show that the Au (plate) dissolves rapidly in the molten solder and forms an intermetallic compound identified as $AuSn_4$. The solder is degraded by the rejection of Pb. Studies of the mechanical strength of joints made with Au plate of various thicknesses on Cu show that the solder joint is materially weakened when the concentration of Au in the solder exceeds 3 to 5%. (auth)

**1874** (WANL-TME-1465) DESIGN AND DEVELOPMENT OF THE ALL-WELDED-AND-BRAZED INSTRUMENTATION PORTS FOR NERVA REACTORS. Kavalkovich, W. (Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.). July 7, 1966. Contract SNP-1. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The design and development of all-welded-and-brazed instrumentation ports for NERVA reactors are discussed. The instrumentation ports permit passage of bundles of instrumentation leads through the pressure vessel wall. Brazing and welding processes are utilized in the port assembly to provide a leak-tight seal between the stainless steel-sheathed instrumentation leads and the reactor's Al pressure vessel. Comprehensive testing demonstrated that the subject assembly remains leak tight (leakage rate less than $10^{-6}$ standard cc $H_2$/sec) through resonant vibrations, hydraulic and structural shock loads and during extreme thermal cycles. (auth)

**1875** STUDIES ON ELECTRODEPOSITION OF TUNGSTEN ALLOYS. V. THE INITIAL STAGE OF ELECTRODEPOSITION OF TUNGSTEN ALLOYS BY USING RADIOISOTOPE $^{185}$W. Kudo, Toshiyuki (Osaka Univ.). J. Metal Finishing Soc. Jap., 17: 255-7(July 1966). (In Japanese).

The determination of trace amounts of W alloys in the initial stage of electrodeposition was studied by using $^{185}$W as tracer. $^{185}$W was found near the cathode at potentials of 20 ~ 40 mV before the first apparent deposition. When the electrolyte was composed of W salt only, $WO_2$ was reduced at the cathode and the reduction was promoted by the addition of hydrazine sulfate. The reduction was decreased by the addition of supporting electrolytes such as tartrate and citrate. Accordingly, the supporting electrolytes had no direct effects on the reduction of W ion, but they formed effective complex salts with Fe, Co, Ni, etc. (auth)

**1876** MACHINABILITY OF REFRACTORY MOLYBDENUM-BASE ALLOYS. Zorev, N. N.; Fetisova, Z. M. Stanki Instr., No. 3, 22-5(1965). (In Russian).

Machining of molybdenum alloys with high-speed steel and sintered carbide tools was investigated. At low cutting speeds corresponding to adhesion-type wear, i.e., up to 35 m/min, the change of feed from 0.044 to 0.4 mm/rev does not affect the life

of high-speed steel tools. At higher speeds corresponding to diffusion-type wear (60 m/min), the effect of feed increase on tool wear is considerable. Depth of cut has the same effect. Hence, at low cutting speeds heavy cuts do not decrease tool life. Cutting fluids decrease the life of high-speed steel tools at low speeds, but increase it at high cutting speeds since in the latter case they lower temperature and slow down the diffusion processes. Increase of rake angle increases the tool life at both low and high speeds in continuous cutting. When machining with sintered carbide tools, feed increase does not change tool life at low speeds (20 m/min max) but raises it at higher speeds (20 to 150 m/min). Cutting fluids increase tool life 10 times at low speeds and 2 to 5 times at high speeds. The fluids also improve surface finish. Optimum rake angle for carbide lathe tools is 10 to 15°. Cobalt-containing R9K5 and R9K10 high-speed steels and VK8 and VK6 sintered tungsten carbide tools proved to be the best for machining molybdenum alloys. Conventional high-speed drills with the undercut web, high-speed steel taps, and high-speed steel or carbide reamers are used for drilling, tapping, and reaming molybdenum alloys. (ATD)

**1877** PREPARATION OF FINE BERYLLIUM AND CARBON FILMS. Malakhov, I. Ya.; Deineko, A. S.; Andreev, G. B. (Inst. of Physics and Tech., Kharkov). Prib. Tekh. Eksp., No. 3, 218-19(May-June 1966). (In Russian).

A method for the preparation of thin films of beryllium and carbon, based on the evaporation in vacuum of these elements on vitreous plates, coated with thin films of potash soap with subsequent dissolution of the soap in water, was described. The thickness of the films obtained is 0.05 to 0.3 $\mu$ for diameters from 7 to 12 mm, respectively. Films of carbon can be used both as targets and as target bases. (tr-auth)

**1878** SPECIAL FABRICATION TECHNIQUES. Reactor Mater., 9: 138-50(Summer 1966).

Melting, casting, hot and cold working, cladding, pressure bonding, welding, brazing, and nondestructive testing techniques for reactor materials are reviewed. (H.D.R.)

**1879** WELDING AND BRAZING. Evans, R. M. Reactor Mater., 9: 142-7(Summer 1966).

Recent research on the welding and brazing of Nb, W, Ti, and Ni-base alloys and on dissimilar materials joining is reviewed. (H.D.R.)

**1880** PLASMA ARC WELDING AEROSPACE MATERIALS. Dyar, J. R.; Swift, M. W. (General Motors Corp., Indianapolis). 33p. (CONF-651150-1). ORAU. Gmelin, AED-CONF-65-328-6.

From 9th National Symposium, Society of Aerospace Materials and Process, Dayton, Ohio.

The characteristics of the plasma arc welding process, the operation principles, and the equipment needed are described. The applications of the process to aerospace weldments and materials up to 0.50-inch thickness are described, and the resulting weld quality and mechanical properties are considered. The principal advantage of the plasma-arc process is reduction of weld time. (D.L.C.)

**1881** ELECTRON-BEAM MELTING AND DROP CASTING OF TUNGSTEN AND TUNGSTEN ALLOYS. Nelson, S. G.; Hildebrand, W.; Foster, E. L. 19p. (CONF-660630-2). ORAU. Gmelin, AED-CONF-66-194-1.

From Vacuum Metallurgy Conference, New York.

A technique was developed for the preparation of high-purity, 200-g cylinder castings of W and W alloys possessing relatively small grain sizes. In this technique, starting materials are melted, consolidated, and alloyed initially by arc melting. Seven or more arc-melted buttons are then combined and are melted and drop cast in an electron-beam furnace. A total of 24 3/4-in.-dia castings were prepared. Most castings contained less than 50 ppM total impurities as determined by mass-spectrographic, gas, and conductometric analyses. (auth)

**1882** PREPARATION OF URANIUM ALUMINIDES $UAl_3$ AND $UAl_{4.5}$. Werner, W. J.; McIlwain, M. C.; Hammond, J. P. (to U. S. Atomic Energy Commission). U. S. Patent 3,288,571. Nov. 29, 1966.

A patent is described relating to a method of forming sinterable powder aluminide of U selected from $UAl_3$ and $UAl_{4.5}$ which comprises heating a mixture of Al and U or $UH_3$ powder to a temperature below the melting point of the desired compound for a period of time sufficient to allow interdiffusion of the reactants. (AEC)

**1883** EXPLOSION APPARATUS FOR FLANGING A TUBE. Frantz, Charles E.; Cawley, William E.; Vlacil, Frank F.; Astley, Eugene R. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,947. Nov. 29, 1966.

An apparatus for producing a flange on the end of a tube by an explosive charge is described. The charge is set off in a chamber of a metal member, and the gases generated expand through openings in the chamber and act against the interior of a rubber sleeve. The sleeve, which engages the inside of the tube at its end, is expanded to form the flange on the tube. (AEC)

**1884** METHOD OF FABRICATING ARTICLES FROM POWDERS. Googin, J. M.; McLaughlin, L. M. (to U. S. Atomic Energy Commission). U. S. Patent 3,284,195. Nov. 8, 1966.

A patent relating to a method of making articles from powders by an isostatic pressing technique using flake graphite as a pressure-transmitting medium is described. (AEC)

## *Properties Evaluations*

*Refer also to abstracts 1310, 1354, 1917, 2284, 2306, 2311, and 2890.*

**1885** (AECL-2627) THE EFFECT OF PREFERRED ORIENTATION OF THE MECHANICAL PROPERTIES AND DEFORMATION BEHAVIOUR OF ZIRCALOY-2 FUEL SHEATHING. Steward, K. P.; Cheadle, B. A. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Aug. 1966. 52p. Dep. mn. AECL $1.50.

Axial tensile, ring tensile, closed end burst, and free end burst tests were carried out at room temperature and 300°C on Zircaloy-2 sheathing covering a wide range of textures and percentages of residual cold work. Knoop hardness tests were also done on all batches. The mechanical properties of the tubes are largely dependent on the percentages of cold work, but are also affected by the textures, particularly with respect to deformation behavior. It is concluded that tubing with a single preferred orientation of radial basal poles shows the best combination of strength and ductility for any given degree of cold work. (auth)

**1886** (AWRE-O-58/66) THE PERMEATION AND DIFFUSION OF HYDROGEN ISOTOPES THROUGH STAINLESS STEELS. PART 4. THE DIFFUSION OF TRITIUM THROUGH S110 AND EN58E STEELS AT 80 DEG C. Jones, P. M. S.; Gibson, R. (Atomic Weapons Research Establishment, Aldermaston (England)). Sept. 1966. 20p. Dep. mn. BIS $0.60. HMSO 3s.

The measured solubility values for these steels were found to be significantly higher than those calculated from high-temperature permeation- and diffusion-coefficient data. The diffusion coefficients, on the other hand, are a factor of 5 to 10 lower than the extrapolated values. Thus the measured and calculated permeation constants at 80°C are lower than the extrapolated values by a factor of approximately four. Reasons for the differences are discussed. (J.R.D.)

**1887** (CALT-221-25) ELECTRICAL RESISTIVITY OF SmAg, SmCu, AND SmAu. Chao, C. C.; Duwez, Pol (California Inst. of Tech., Pasadena. W. M. Keck Lab. of Engineering Materials). Nov. 1966. Contract AT(04-3)-221. 12p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Electric resistivity vs. temperature curves of the three equiatomic phases of Sm with Cu, Ag, and Au show several anomalies, which are probably related to magnetic transitions. The fact that the curves show very little similarity is probably due in part to the different crystal structures of these three phases, which in turn indicates a lack of similarity in the alloying behavior of Cu, Ag, and Au with Sm. The SmCu and SmAu phases can be made to crystallize into a CsCl structure isomorphous with SmAg by rapid quenching from the liquid state. However, in the process of quenching, these two alloys break up into small pieces only a few mm in length and no reliable electrical resistivity measurements were obtained. Measurements on the rapidly quenched alloys would make possible a direct comparison of the magnetic properties of the three Sm phases with Cu, Ag, and Au with the same CsCl type crystal structure. (auth)

**1888** (EURAEC-1732) SOME PHYSICAL CHARACTERISTICS OF AISI TYPE 304 CONTAINING NITROGEN. Report 438-B. THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION. (Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering). Sept. 1966. Contract AT(40-1)-3208. 34p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

An investigation of physical characteristics of type 304 stainless steel containing varying amounts of $N_2$ has shown that the proportional limit and the work hardening rate at 150°C increase with $N_2$ content. A very marked increase in work hardening rate occurred when the $N_2$ content exceeded the solid solubility limit. Volume contractions found at 70 to 170°C are believed to be caused by stress-induced diffusion of $N_2$ resulting either in $N_2$ concentrations around crystalline defects in austenite or precipitation of nitrides.

A small amount of ferromagnetism was observed in the higher $N_2$ content alloys which is believed to be caused by small amounts of the $Fe_4N$ structure in the alloys. (auth)

**1889** (KAPL-3145) TENSILE AND CREEP PROPERTIES OF NIOBIUM–VANADIUM ALLOYS AS INFLUENCED BY STRAIN RATE. Calhoun, C. D.; Wiesinger, F. W. (Knolls Atomic Power Lab., Schenectady, N. Y.). June 1, 1966. Contract W-31-109-eng-52. 23p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The strain-rate sensitivity of Nb-2 and Nb-6 wt % V was studied at 315 to 649°C. Notched tensile specimens were tested with crosshead speeds of 0.025 and 2.0 in./min. These alloys exhibited little variation in ductility or notch strength as a function of strain rate and/or temperature. These phenomena are explained by a strain-aging reaction which is operative in this temperature range. Creep tests were performed at 315 to 649°C. The specimens were step-loaded in tension for times of 200 to 1800 hr. Associated with each additional stress increment was either no deformation or fast deformation, which changed to either: (1) no further increase in strain, (2) a slow creep rate, or (3) continuation of deformation to failure. This behavior is also indicative of the strain-aging phenomenon found in this temperature range. (auth)

**1890** (N-66-22355) INVESTIGATION OF HIGH STRAIN RATE BEHAVIOR OF REFRACTORY ALLOYS AND COATINGS. Final Report. Miyagishima, T. (Marquardt Corp., Van Nuys, Calif.). Feb. 1966. Contract NAS9-4905. 234p. (NASA-CR-65319; PR-3009-F). CFSTI $6.00 cy, $1.25 mn.

Selected refractory alloys, both coated and uncoated, were evaluated under the environmental loading conditions to which rocket engine combustion chambers are subject as a result of ignition pressure spikes, to generate high strain rate data and establish engineering and design criteria. Emphasis was placed on determining the effects of single and repeated high dynamic strains. Good strength and ductility resulted under high strain rate loading for Nb-10Hf-1Ti-1Zr for tensile, bend, and full scale chamber testing. Good strength and reasonably good ductility also resulted for Nb-10W-10Hf. Both of these are recommended as important chamber candidate materials. It is also reported that Ta-10W materials system exhibited good strength and ductility with tensile specimens and full scale chamber testing; however, the results of bend testing after torch exposure showed an appreciable loss of ductility. It is noted that the ultimate strength performance values of ductile materials, coated and uncoated, tested at high strain rates were found to be 50 to 100% higher than strength values obtained under slow strain rate conditions. (D.T.)

**1891** (NASA-CR-610) SOLUBILITY STUDIES OF ULTRA PURE TRANSITION ELEMENTS IN ULTRA PURE ALKALI METALS. McKisson, R. L.; Eichelberger, R. L.; Dahleen, R. C.; Scarborough, J. M.; Argue, G. R. (North American Aviation, Inc., Canoga Park, Calif.). Oct. 1966. Contract NAS 3-4163. 153p. CFSTI $3.25 cy, $1.00 mn.

Solubilities of Fe, Mo, Nb, and Ta in liquid potassium were studied in the temperature range 800 to 1200°C under high vacuum with emphasis on achieving a true two component experimental system. Least squares curves were fitted to the data, using six points for Fe at 800 to 1000°C, six points for Mo at 1000 to 1200°C, and twelve points for Ta at 800 to 1200°C. $\Delta H$ of solution from these curves is 7700, 25,500, and 13,200 cal/mol for Fe, Mo, and Ta, respectively. The high values for Mo and Ta suggest that there may be a reaction involved in the solution process. Twelve measurements for Nb at 1000 to 1200°C showed a scatter between 15 and 171 wppM, and no curve was determined. Two experiments were completed with Nb-1% Zr alloy, at 1000 and 1200°C. The Nb concentration found was <1 wppM (not detected) and 6 wppM, respectively. It is apparent from the data that the solubility process for metals in liquid K is still not understood, although great care was taken to prepare and maintain high-purity materials in this work. Tables are included for previous solubility studies, including Li, Na, K, Rb, and Cs. (153 references). (auth)

**1892** (NLCO-984) ELECTRONICALLY CONTROLLED UNIVERSAL TESTING MACHINE FOR ELEVATED TEMPERATURE TESTING OF URANIUM. Wexlin, L. G.; Neu, C. A. (National Lead Co. of Ohio, Cincinnati). Oct. 4, 1966. Contract AT(30-1)-1156. 18p. (CONF-661022-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn

From 16th Annual National Lead Company Analytical and Physical Testing Symposium, West Caldwell, N. J.

An electronically controlled universal testing machine is described having a load frame of 120,000 pound capacity and a hydraulic system with a double-acting piston that can be driven at rates as high as 20 in./min. Control by electronic feedback permits tension or compression testing using stress, strain, or table position as the controlled variable. It is also possible to perform cyclic tests of various types such as tension-tension, tension-compression, and similar combinations using a signal generator, magnetic tape, or other source of electronic wave forms to control the machine. All electronic equipment is consolidated in a console which includes a strip chart recorder and an X-Y plotter. (auth)

**1893** (BNL-tr-101) EXPERIMENTAL INVESTIGATION OF THE TEMPERATURE GRADIENT EFFECT ON THE DISTRIBUTION OF HYDROGEN IN ZIRCONIUM. Emel'yanov, V. S.; Borkov, N. V.; Evstiukhin, A. I.; Kazakevich, A. T. Translated by Stephen J. Amoretty (Brookhaven National Lab., Upton, N. Y.), from Met. Metalloved. Chistykh. Metallov. Sb. Nauch. Rabot, 5: 12-21(1966). 16p. Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $1.60 fs, $0.80 mf.

An apparatus for obtaining a temperature gradient along the height and radius of cyclindrical samples was described. It was determined that under the influence of the temperature gradient the hydrogen in zirconium migrates from the heated to the cooled walls. It was also determined that the curves giving the variation of hydrogen concentration due to the temperature gradient effect indicate a maximal hydration under the specified conditions in those regions, where the temperature fluctuations are within the limits of 245 to 260°C. (auth)

**1894** TANTALUM THERMOPHYSICAL PROPERTIES AT TEMPERATURES ABOVE 1000 DEGREE K. Peletskii, V. E.; Voskresenskii, V. Yu. (Scientific-Research Inst. of High Temperatures, USSR). Teplofiz. Vysok. Temp., 4: 336-42(May–June 1966). (In Russian).

Thermal and electric conductivity and integral backing of Ta were measured at 1300 to 2900°K. The results were compared to published data. The applicability of the Wiedemann-Franz law to Ta was analyzed. (tr-auth)

**1895** HEAT RESISTANCE OF PRECIPITATION-HARDENED TUNGSTEN AND COPPER. Opara, B. K.; Zhuk, N. P. (Inst. of Steel and Alloys, Moscow). Izv. Vyssh. Ucheb. Zaved., Tsvetn. Metal., No. 2, 136-9(1965). (In Russian).

A report is given on an investigation into the heat resistance of W with additives of various amounts of $ThO_2$ and 1% $LaO_2$ in air, and also Cu, strengthened with Mg, Zr, and Al oxides, and BN. The kinetics of the air oxidation of W were investigated from 700 to 900°C, and Cu at 800°C. Depending on the additive, the oxidation of both metals progress linearly or in a form similar to a quadratic parabola. The oxidation was controlled by the process of diffusion. The addition of $ThO_2$ and $LaO_2$ actually accelerates the process of W oxidation. It is suggested that the addition of small amounts of MgO, $Al_2O_3$, and $ZrO_2$ to Cu reduce the oxidation rate due to increased compactness of the $Cu_2O$ crystal lattice, while further addition of these additives increases the oxidation rate in accordance with the theory of Wagner. (JPRS)

**1896** RECRYSTALLIZATION OF Mg–Li ALLOYS. Sviderskaya, Z. A.; Trokhova, V. F. Izv. Akad. Nauk SSSR, Metal., No. 2, 147-52(1965). (In Russian).

A study was made of the effect of 0.2 to 18 at. % lithium on the recrystallization temperature of magnesium cold deformed 60% in a hydraulic press and reheated to temperatures between 50 to 250°C. X-ray (appearance of the first spot on the Debye ring) and metallographic (appearance of first recrystallized grain) examinations were used to map the onset of recrystallization. The disappearance of the last traces of cold-worked structure under metallographic examination and the complete breakdown of Debye rings into spots signified the end of recrystallization. A noticeable increase in recrystallization temperature occurs only with the addition of 6 to 7% Li although even with an 18% Li addition the recrystallization temperature is raised only 45°C compared with pure magnesium. The curves for log of time to beginning of recrystallization versus reciprocal of the temperature of annealing for the 0.0, 0.2, 3.3, and 6.8% specimens gave straight lines and equal slopes for the latter three alloys indicating a constant activation energy for the process. The activation energy for pure Mg was found to be higher. The high activity of lithium or the lowered energy of grain boundary surfaces due to Li concentration is offered as an explanation for the relative reduction in recrystallization temperature for small additions of lithium. (ATD)

**1897** MODERATOR MATERIALS. Reactor Mater., 9: 91-8 (Summer 1966).

The development of graphite, Be metal and alloys, BeO, and solid hydrides is reviewed. (H.D.R.)

**1898** NUCLEAR POISONS. Reactor Mater., 9: 99-102(Summer 1966).

The development of metallic, dispersion, and nonmetallic poison materials is reviewed. (H.D.R.)

**1899** CLADDING AND STRUCTURAL MATERIALS. Reactor Mater., 9: 103-37(Summer 1966).

Corrosion, metal-water reactions, radiation effects, mechanical properties, metallurgical aspects, diffusion studies, and ceramic

technology developments are reviewed for fuel element cladding and reactor structural materials. (H.D.R.)

**1900** SELECTED MECHANICAL PROPERTIES OF CLADDING AND STRUCTURAL MATERIALS. DeMastry, J. A. Reactor Mater., 9: 117-23(Summer 1966).

Mechanical properties measurements on Fe- and Ni-base alloys and refractory metals and alloys are reviewed. (H.D.R.)

**1901** SELECTED METALLURGICAL ASPECTS OF CLADDING AND STRUCTURAL MATERIALS. Kangilaski, M. Reactor Mater., 9: 123-31(Summer 1966).

Metallurgical studies on light metals, Zr and Zr alloys, Ni alloys and steels, and refractory metals are reviewed. (H.D.R.)

**1902** HEAT CAPACITY OF ALPHA URANIUM FROM 1.7 TO 25°K. Flotow, Howard E.; Osborne, Darrell W. (Argonne National Lab., Ill.). Phys. Rev., 151: 564-70(Nov. 11, 1966).

The heat capacity of high-purity $\alpha$ U was determined from 1.7 to 23°K and smoothed into previous data at 25°K. These heat capacities are significantly lower than the values reported by other investigators. The values for $\gamma$, the coefficient of the electronic contribution to heat capacity, and for the Debye $\Theta$ at 0°K, were determined to be $9.88 \pm 0.05$ mJ deg$^{-2}$ (g at.)$^{-1}$ and $222 \pm 2$°K, respectively. The $C_p - C_v$ correction was evaluated between 15 and 80°K to show the effect of the anomalous expansive and compressive behavior of U between 20 and 45°K on the lattice heat capacity. Tabular values of $C_p$, $C_v$, $\Theta$, and other thermodynamic quantities are presented up to 25°K. (auth)

**1903** ZIRCONIUM BASE NUCLEAR REACTOR ALLOY. Klepfer, Harold M. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,111. Nov. 22, 1966.

This patent pertains to alloys of Zr, and in particular to an alloy of Zr having a low corrosion and hydriding rate in boiling water and steam at temperatures below 500°C. The alloy consists essentially of about 1.7 to 2.3 at. % Cr, 0.1 to 0.2 at. % Fe, the remainder being Zr. A portion of the Cr is dispersed as finely divided particles of $ZrCr_2$. (auth)

## *Structure and Phase Studies*

*Refer also to abstracts 1672 and 1917.*

**1904** (AECL-2599) HYDROGEN SUPERSATURATION IN ZIRCONIUM AND ZIRCONIUM-2.5 WT. PERCENT NIOBIUM. Coates, D. E. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). July 1966. 20p. Dep. mn. AECL $0.50.

A study of pressure-composition-temperature (P-C-T) relations for low concentrations of $H_2$ in Zr and Zr-2.5 wt% Nb was made. The results show $\alpha$-solid solutions exhibit high degrees of supersaturation on cooling from $\alpha$-solid solution regions. The presence of Nb was found to enhance the degree of this supersaturation effect. (auth)

**1905** (BM-RI-6866) INTERMEDIATE PHASES IN THE MAGNESIUM-CERIUM SYSTEM BETWEEN MAGNESIUM AND $Mg_3Ce$. Crosby, R. L.; Holman, J. L. (Bureau of Mines, Rolla, Mo. Rolla Metallurgy Research Center). Mar. 1966. 18p. Bureau of Mines Free.

Microscopic and x-ray-diffraction techniques were used to identify two intermediate phases in that part of the solid region of the Mg-Ce system between Mg and $Mg_3Ce$. Previous literature had reported only one intermediate phase for this region, but chemical analysis determined the approximate composition of the two compounds to be $Mg_{23}Ce_2$ and $Mg_{17}Ce_2$. The range in composition of the two intermediate phases was found to be limited to less than 0.3 at. % Ce. The crystal structure of $Mg_{17}Ce_2$ was not determined, but that of $Mg_{23}Ce_2$ is tetragonal with $a = 10.33$ Å and $c = 19.51$ Å. (auth)

**1906** (MCW-1503) PHASE STUDIES OF THE URANIUM-IRON-ALUMINUM TERNARY SYSTEM WITH THE ELECTRON MICROPROBE. Schierding, R. G.; Fergason, L. A. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). Aug. 1, 1966. Contract W-14-108-eng-8. 20p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The solubility limits of Fe and Al in the U allotropes and in the intermetallic phases $U_6Fe$ and $UAl_2$ were determined by electron microprobe analysis. The U-rich portion of the U-Al phase diagram was presented along with isothermal sections of the U-rich corner of the U-Fe-Al ternary system. (auth)

**1907** (MCW-1506) BETA-TO-ALPHA TRANSFORMATION CHARACTERISTICS OF SOME DILUTE URANIUM ALLOYS. Nolan, M.F. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). Aug. 1, 1966. Contract W-14-108-eng-8. 32p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Equipment is described for isothermal quenching of thin U alloy samples from either $\beta$ or $\gamma$ phase temperatures into a molten metal bath at selected $\alpha$ temperatures. TTT diagrams are presented for four alloys ranging from U-Si and U-Al binaries to Fe-Si-Al-Cr alloys. Two modes of transformation are reported as the general case, that in the upper temperature region being a diffusion-controlled nucleation and growth mechanism, and that at lower temperatures acting by shear. An intermediate nose is reported for a centrifugally cast high-Al alloy; in this region the transformation appeared to be by a combination of shear and diffusion. Quenching this same alloy from the gamma phase yields a TTT diagram with only a single nose; transformation at this nose appeared again to be by a mechanism of mixed shear and diffusion. (auth)

**1908** (JPRS-37980) INTERNAL FRICTION IN METALS AND ALLOYS. Translated from pp 36; 130-3; 166-9; 190-3; 238-41 of Vnutrenneye Treniye v Metallakh i Splavakh, Academy of Sciences, Moscow, 1966. 24p. (TT-66-34407). CFSTI $1.00 cy, $0.50 mn.

Information and discussion are presented on internal friction in B, temperature dependence of internal friction in hardened Fe and alloy steel, internal friction in Be-BeO cermets, devices for internal friction measurement, and diffusion internal friction in polycrystals. (J.R.D.)

**1909** ELECTRON EMISSION DURING MELTING AND SOLIDIFICATION OF METALS. Kahlert, H.; Kralik, G. (Univ., Vienna). Acta Phys. Austr., 23: 303-11(1966). (In German).

The electron emission during the solidification of metals found earlier only in studies with Geiger-Mueller tubes was investigated comparatively in counters with a secondary electron multiplier in high vacuum. An emission both in solidification and also in melting was found in the counter tube and in the high vacuum. This emission is connected to the presence of an oxide layer and occurs sharpest at a given layer thickness. This emission is explained as tribo-Co electron emission from the mechanically deformed oxide layer in the phase transformation of the basic metal. (tr-auth).

**1910** SOLUBILITY OF CERIUM IN BERYLLIUM. Papirov, I. I.; Smirnov, Yu. M.; Tikhins'kii, G. P.; Finkel', V. O. Ukr. Fiz. Zh., 11: 922-3(1966). (In Ukrainian).

An attempt was made to determine the solubility of Ce in Be by measuring the lattice parameters of a Be alloy containing 0.35% Ce at -195 to 1200°C. The data indicated that at 720°C, the solubility of Ce was 0.35% and drops continuously with decreasing temperatures to about 0.06% at room temperature. Little or no change occurs with further decreases of temperature to that of liquid nitrogen. (ATD)

**1911** THE EFFECT OF SMALL ALUMINUM ADDITIONS ON THE STRUCTURE OF URANIUM-MOLYBDENUM ALLOYS. Lazarevic, Dorde (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Tehnika (Belgrade), No. 3, 515-19(1966). (In Serbo-Crotian).

A series of uranium-molybdenum alloys containing 0.4 to 0.6% molybdenum (a material for fuel elements of gas-cooled reactors) were studied in order to determine the effect of small additions (500 to 1500 ppm) of aluminum on the alloy structure. The experiments showed that aluminum, which is almost insoluble in uranium, forms numerous nucleation centers, thereby prevents an extensive grain growth, and reduces the anisotropy, which in alloys with low molybdenum contents leads to buckling of the fuel elements. An alloy containing 0.6% molybdenum and 500 ppM aluminum has the smallest and most uniform grain size: 0.04 to 0.06 mm. (ATD)

**1912** EFFECT OF ULTRASONIC VIBRATION ON THE STRUCTURE OF ELECTRON-BEAM MELTED MOLYBDENUM. Zaboronok, G. F.; Milova, V. B.; Polyakova, M. D.; Simonishvili, T. V. Tsvetn. Metal., No. 7, 83-5(1966). (In Russian).

The effect of subsonic and ultrasonic vibrations on the crystallization of molybdenum, electron-beam-melted in a $5 \times 10^{-4}$ mm Hg vacuum, was investigated. Subsonic vibrations at a frequency of 1000 cycle/min reduced the grain size from 3 to 5 mm to 2 to 3 mm. Ultrasonic vibrations with a frequency of 2 to 18 kilocycle substantially reduced the grain size in the transverse direction but had very little effect on the grain size in the longitudinal direction, leaving the columnar structure unchanged. The Brinell hardness of molybdenum melted with ultrasound amounted to 153 to 156 kg/mm$^2$, i.e., was of the same order as that of molybdenum melted without ultrasound. Preforged ingots were rolled into sheets 1-mm thick. The respective tensile strength and elongation of cold-rolled sheets melted with ultrasound were 75.0 kg/mm$^2$ and 4.8% compared to 62.1 kg/mm$^2$ and 2.8% for conventionally electron-beam-melted metal. Vacuum annealing at 600 to 1400°C for 1 hr greatly affected the strength and ductility of convention-

ally melted metal, but affected much less those of metal melted with the application of ultrasound. (ATD)

**1913** CHARACTER OF STRUCTURAL TRANSFORMATIONS IN DEFORMED ALLOY Ni + 10 PERCENT (AT.) Mo. Dubrovina, A. N.; Umanskii, Ya. S. (Inst. of Steel and Alloys, Moscow). Izv. Vyssh. Ucheb. Zaved., Chern. Met., No. 5, 140-3(May 1966). (In Russian).

A nickel alloy containing 15.1 wt % Mo, melted in an induction furnace, with not more than 0.5% unavoidable impurities, was studied. Two batches of specimens, quenched (1200°C, 30 minutes, water) and deformed after quenching, were annealed at 500 to 700°C for 10 minutes to 100 hours. Changes in electrical resistance and hardness of the quenched specimens in the course of annealing were small and close to experimental error. The electrical resistance of the quenched specimens was higher than that of the deformed; consequently, after quenching the atomic arrangement was nonchaotic (close-ordered). Hardness of the deformed specimens in the annealing process increased from Bhn 275 to approximately Bhn 420. Processes leading to the hardness increase proceeded more rapidly at 600°C than at 500°C. At 700°C, the hardness initially increased but later, in connection with the initiation of recrystallization, was reduced. The electrical resistance of the deformed specimens in the annealing process was increased by approximately 6%. Shapes of the diffraction lines (111), (200), (311), and (222) of deformed and annealed specimens were photographed. In lines (200) and (311), satellites appear from the direction of small angles; this attests to the appearance of a new phase in the alloy. This phase can have a lattice of the gamma-solid solution and be enriched with molybdenum (increase of the Mo content in the solution leads to the increase of its lattice period). In specimens deformed 40%, it was possible to observe weak satellites in lines (200) and (311) of the specimens annealed at least 5 hours at 600°C and not less than 10 hours at 500°C. Characteristics of intensity distribution are the same as in strongly deformed specimens. Deformation of the investigated alloy results in the appearance of microdistortions. Nickel and molybdenum atoms have different radii; hence, during annealing, a rising diffusion of Mo atoms in parts with an elongated lattice and the emergence of a concentrated inhomogeneity in the alloy are possible. Such a structure provides for high hardness. Thus, the roentgenographic study indicated that the K state in the deformed and annealed alloy of Ni–10 at. % Mo was associated with the formation, in the annealing process, of parts with the ordered structure of $Ni_4Mo$ having an increased content of Mo in comparison with the average content, since the K state in the quenched and annealed specimens is explained by the existence of close ordering per the $Ni_4Mo$ type. (JPRS)

## Radiation Effects

*Refer also to abstracts 2298, 2332, and 2334.*

**1914** (AD-630923) NEUTRON IRRADIATION AND THE YIELD SURFACES OF COPPER. Dudderar, T. D.; Duffy, J. (Brown Univ., Providence, R. I. Div. of Engineering). Jan. 1966. Contract Nonr-562(20). 86p. (TR-48). CFSTI $8.60 cy, $0.75 mn.

Tests were conducted to determine the effects of irradiation and plastic deformation on the yield surfaces of polycrystalline Cu. It was found that the principal effect of plastic deformation on unirradiated Cu was to translate the yield surface without appreciably changing its size or shape. Irradiation, on the other hand, produced an effect phenomenologically similar to extensive isotropic strain-hardening. In addition, the shape of the initial yield surface after irradiation was dependent on the plastic strain offset chosen to define yield. This effect was not observed for the unirradiated metal. Extensive plastic deformation after irradiation caused the yield surface to translate and grow smaller without significantly changing shape. (auth)

**1915** (AD-641283) NEUTRON SPECTRAL CONSIDERATIONS AFFECTING PROJECTED ESTIMATES OF RADIATION EMBRITTLEMENT OF THE ARMY SM-1A REACTOR PRESSURE VESSEL. Serpan, C. Z. Jr.; Steele, L. E. (Naval Research Lab., Washington, D. C.). Aug. 12, 1966. 24p. (NRL-6474). CFSTI $1.00 cy, $0.50 mn.

Measurements of the neutron spectra at the SM-1A pressure vessel wall and at sample-exposure locations in the LITR are described. Methods are described for analyzing these spectral data to establish more accurately an anticipated maximum allowable pressure vessel exposure in terms of reactor power output for use in developing critical nil-ductility transition values for the SM-1A pressure vessel. (J.R.D.)

**1916** (BNWL-324) ALPHA AUTORADIOGRAPHY OF IRRADIATED MATERIALS. Hascall, J. L. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 1966. Contract AT(45-1)-1830. 6p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Preparation, exposure, processing, and photographic reproduction of pure cellulose nitrate plates are discussed. It is noted that $\alpha$ autoradiography, using cellulose nitrate has many applications in the study of irradiated materials. Such applications include differentiating $PuO_2$ from $UO_2$ in mixed oxide fuels, migration studies, $\alpha$ radiation energy studies, and, when used in conjunction with $\beta$-$\gamma$ autoradiography and optical metallography, providing information that might have passed undetected. The preparation and use of the pure cellulose nitrate plate enhances these studies because there are no artifacts or background to distract from the desired information. (J.R.D.)

**1917** (BNWL-SA-672) ZIRCONIUM CLADDING ALLOYS. Bement, A. L. Jr. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). May 3, 1966. Contract AT(45-1)-1830. 46p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A review reveals that Zircaloy-2 has proven to be a reliable cladding material for ceramic fuel elements for BWR and PWR systems to burnups of 20,000 MWd/t and that thermal-mechanical treatments and fabrication methods were developed for Zr–Nb alloys encouraging further use of these alloys for fuel cladding. Data on fabrication textures, deformation mechanisms, corrosion mechanisms, and neutron irradiation damage was accumulated on the Zircaloys for hot-water service conditions and are being obtained for other alloy systems and higher temperature service conditions. Favorable neutron properties and falling material costs gave Zr alloys an economic advantage over stainless steel and Ni-base alloys for most commercial reactor applications. Research required to further develop Zr cladding alloys is outlined. (J.R.D.)

**1918** (GEAP-5002) FISSION FRAGMENT DAMAGE TO TYPE-304 STAINLESS STEEL FUEL CLADDING. Rosenbaum, H. S.; Armijo, J. S.; Wolff, U. E. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Jan. 1966. Contract AT(04-3)-361. 33p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

During the examination of irradiated cladding from experimental fuel rods, the inner surface of the type-304 stainless steel cladding was found to have a duplex-layered structure 5 to 10 $\mu$ thick. This structure is within the range of recoiling fission fragments and is believed to be a fission-damaged zone. Examination of the zone by metallography, electron microscopy, and with colloidal magnetite showed that both layers of the duplex structure are austenitic and have the same crystallographic orientation as the underlying austenitic matrix. Both layers are harder than the underlying matrix, yet they are readily distinguished by their different etching characteristics. Possible reasons for the existence of the duplex, rather than a single layer, are discussed. (auth)

**1919** (N-66-23762) RADIATION EFFECTS ON SILVER AND ZINC BATTERY ELECTRODES. [PART] III. Interim Report, October 1965–January 1966. Nicholson, M. M.; Recht, H. L.; Schlesinger, G.; McCollum, W. A. (Atomics International, Canoga Park, Calif.). Mar. 21, 1966. Contracts NAS7-100; JPL-951109. 39p. (NASA-CR-74240; AI-66-33). CFSTI $2.00 cy, $0.50 mn.

For Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

Investigation continued on Ag electrodes in experimental cells with Cd counter electrodes, with emphasis on improving accuracy in the discharge capacity and gas evolution data. Steps were taken to better standardize the discharge current density and depth of the conditioning cycle, to reduce ohmic drop effects in the recording and current control circuits, and to establish a well defined gas atmosphere before the irradiation step. In closely matched cells at 90% state of charge, with capacity limited by the Ag electrode, a capacity increase of 15% was observed for the system receiving $7 \times 10^7$ rads ($H_2O$) of $^{60}Co$ gamma radiation. An increase of 12% was observed for the control cell maintained at the same temperature. A minor quantity of $H_2$, again detected in irradiated cells, was shown to originate from the polystyrene cell liner and/or the electrolyte solution in the absence of electrodes. (R.N.A.)

**1920** (AI-Trans-220) EFFECT OF IMPURITIES ON THE RECOVERY STAGES OF ELECTRICAL RESISTIVITY IN NICKEL BOMBARDED BY ELECTRONS AT LOW TEMPERATURES. Oddou, J. L.; Minier-Cassayre, C.; Moser, P. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Translated for Atomics International, Canoga Park, Calif., from report BP-269. 6p. Dep. mn. JCL $1.10 fs, $0.80 mf.

The isochronal recovery curves of the resistivity increase $\Delta\rho$ were plotted for electron-bombarded samples of pure Ni and Ni containing impurities. The comparison of these curves exhibits the interaction between point defects created by irradiation and impurities. (auth)

**1921** CHANGES IN MECHANICAL PROPERTIES OF ANNEALED ALUMINUM ALLOY FOLLOWING IRRADIATION IN A NUCLEAR REACTOR. Kuznetsova, A. P.; Sharov, B. V. At. Energ. (USSR), 21: 60-2(July 1966). (In Russian).

The mechanical properties of an Al-base alloy, containing 0.6 to 1.2% Si and 0.45 to 0.9% Mg, designated as Type SAV-1 alloy, used as a structural component in the beamhole of the Institute for Theoretical and Experimental Physics, were examined. The tube was in contact with <80°C heavy water during the operation of the reactor; it was placed in service after hardening and aging, removing specimens by means of a punch die. The tests carried out after two years of operation of the reactor, corresponding to an exposure to about $10^{20}$ n/cm$^2$, indicated that the hardened alloy becomes stronger and less plastic. Changes were observed on portions which were within and on those which were outside of the core. Creep tests were also made to determine the residual deformation and the fracture stress. It was found that irradiation did not affect the residual deformation but aging did change the mechanical properties. In this respect, exposure while being used in a reactor corresponds to artificial aging. Exposure to $6 \times 10^{20}$ n/cm$^2$ did not affect the modulus of elasticity of the alloy which was 7080 ± 200 kg/mm$^2$. It is concluded that the changes are due to aging and not to exposure. (TTT)

**1922** RADIATION EFFECTS IN NONFUEL MATERIALS. Shober, F. R. Reactor Mater., 9: 111-17(Summer 1966).

Radiation effects studies on mild and alloy steels, stainless steel, Ni-base alloys, and Zr alloys are reviewed. (H.D.R.)

**1923** RELIABILITY OF COMPONENTS UNDER RADIATION STRESS. PROBLEMS TO BE SOLVED AND SOME EXPERIMENTAL RESULTS. Blin, A.; D'Harcourt, A.; Le Ber, J. (CEA, Paris). Onde Elec., 46: 945-54(Sept. 1966). (In French).

A method is described which permits the prediction of reliability of electronic circuits and components under radiation stress when the statistical behavior of each component entering the circuit is known. Results obtained by the statistical treatment are given for transistors, resistors, capacitors, condensers, and semiconductors. (F.S.)

**1924** ENGINEERING SIGNIFICANCE OF FERRITE GRAIN SIZE ON THE RADIATION SENSITIVITY OF PRESSURE VESSEL STEELS. Gordon, G. M.; Klepfer, H. H. (General Electric Co., Pleasanton, Calif.). 30p. (CONF-660627-6). ORAU. Gmelin, AED-CONF-66-198-5.

From American Society for Testing and Materials, 69th Annual Meeting, Atlantic City.

A mathematical model was developed to describe the effect of ferrite grain size on the nil ductility temperature increase observed in irradiated pressure vessel steels. Experimental data illustrating the grain size effect are presented. The engineering significance of both the theoretical model and the experimental data are discussed, and it is shown that the neutron embrittlement problem is greatly minimized by use of fine-grained steels. For A302B and A212B steels, shifts of less than 65°F in the 30 ft-lb Charpy transition temperature at an exposure of $3 \times 10^{19}$ nvt (>1 Mev) can be obtained with a ferrite grain size smaller than ASTM 9. The model may be used for predicting dose rate effects for fine-grained steels irradiated at relatively high temperatures and for long times or both. (auth)

# Ceramics and Cermets

*Refer also to abstract 1866.*

## Corrosion and Erosion

**1925** (BNWL-295) WASHOUT TESTING OF MIXED OXIDE CERAMIC CORE FUEL ELEMENTS. Hayden, K. D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 1966. Contract AT(45-1)-1830. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The washout of core material following fuel element failure was evaluated in the Irradiated Rupture Prototype (IRP) Loop. The irradiated elements were defected with a long slit and placed in a shielded test section which was connected directly to the loop. The water in the loop was then heated, and the test was run for several weeks. The release of core material was determined by weighing the fuel element, by visual inspection, and by continuous measurements of activity levels in different portions of the loop. It was found that swaged elements tend to be more resistant to washout than vibrationally compacted elements. It was also found that the amount of core material washed out depends on the amount of vibration and that core washout without externally applied vibration tends to be small even with large defects in the cladding. (J.R.D.)

**1926** (CONF-661003-8) CHEMICAL AND THERMAL STABILITY OF A BeO-BASE FUEL SYSTEM IN AN OXIDIZING ENVIRONMENT. Aitken, E. A.; Brassfield, H. C.; Turner, P. P. (General Electric Co., Cincinnati, Ohio. Nuclear Materials and Propulsion Operation). [1966]. Contract AT(40-1)-2847. 28p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From AIME Nuclear Metallurgy Symposium on High Temperature Nuclear Fuels, Delevan, Wis.

A high-temperature BeO-base fuel system that is essentially thermodynamically stable in any oxidizing gaseous environment, is described. The fuel is a solid solution of $UO_2$ and $Y_2O_3$ dispersed in the BeO. The chemistry of the BeO–$UO_2$–$Y_2O_3$ fuel system is discussed in terms of oxidation and vaporization kinetics, for both the $UO_2$–$Y_2O_3$ solid solution and for the solid solution dispersed in high density BeO. It was observed that the amount of $Y_2O_3$ necessary to prevent precipitation of $U_3O_8$ was a function of the $O_2$ partial pressure. The addition of 33 mole % $Y_2O_3$ to the $UO_2$ prevented precipitation of $U_3O_8$ when the fuel was oxidized in air. However, 70 mole % $Y_2O_3$ was required to reduce the vapor pressure of $UO_3$ gas over the $UO_2$–$Y_2O_3$ solution by a factor of $10^3$ relative to the vapor pressure over $U_3O_8$. Oxidation of the solid solution was diffusion controlled; 10μ powders were fully oxidized in a few minutes when heated above 500°C. (auth)

**1927** (NUMEC-3463-13) WATER AND STEAM CORROSION CHARACTERISTICS OF MIXED PLUTONIUM–URANIUM OXIDE PELLETS. Marley, Jack L. (Nuclear Materials and Equipment Corp., Apollo, Pa.). Jan. 24, 1966. Contract AT(30-1)-3463. 54p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Corrosion tests in neutral, degassed water and steam and in modified media were made with pellets of $PuO_2$–$UO_2$. The pellets which contained 1, 5, and 15 wt % $PuO_2$ were prepared by coprecipitation and by mechanical blending of the mixed oxides. Substoichiometric and superstoichiometric pellets were prepared for the tests. No significant differences in corrosion behavior were observed in any of the tests. Pellets which were contained in intentionally defected Zircaloy-2 tubes were as corrosion resistant as pellets which were tested individually. (auth)

## Preparation and Fabrication

*Refer also to abstracts 1884, 2821, and 2864.*

**1928** (BNWL-SA-482) FABRICATION OF REFRACTORY COMPOSITES BY PNEUMATIC IMPACTION. Robinson, R. K.; Sump, K. R. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan. 17, 1966. Contract AT(45-1)-1830. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A process used to consolidate and shape ceramic powders and powdered cermets into high-density materials is described. Blended powders are heated to 3300°F in vacuo, transferred to high energy-rate forming machine, and impacted at pressures up to 400,000 psi. Semi-works production processes were developed for high-density complex shapes of ceramic dispersions in refractory metal matrices. (J.R.D.)

**1929** (LA-3569) CARBIDE-GRAPHITE COMPOSITES. Davidson, K. V.; Riley, R. E.; Taub, J. M. (Los Alamos Scientific Lab., N. Mex.). July 14, 1966. Contract W-7405-eng-36. 61p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The effects of process variables on the high temperature properties of hot pressed carbide-graphite composites is not well understood. A program to evaluate these effects by holding certain variables constant is described. The results of the effects of these variables are reported and include powder characterization, hot pressing conditions, composition, carbide versus metal powder additions, binder content, graphite particle size and type, and correlation of microstructures with resistance to deformation at elevated temperatures. (auth)

**1930** (ORNL-TM-1118) A PROGRESS REPORT ON SOL-GEL PROCESS DEVELOPMENT AT OAK RIDGE NATIONAL LABORATORY. Wymer, R. G. (Oak Ridge National Lab., Tenn.). Apr. 22, 1965. Contract W-7405-eng-26. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Developments in the sol-gel process for preparing $ThO_2$, $UO_2$, and $ThO_2$–$UO_2$ microspheres are described. Principal product shortcomings at the present stage of development are high-carbon content and low-crushing strength. Development work is being directed toward solving these problems. Future plans for the sol-gel process are described. (P.C.H.)

**1931** GRAPHITE–CARBIDE MATERIALS PREPARED BY HOT-WORKING WITH A DISPERSED LIQUID-CARBIDE PHASE. White, J. L.; Pontelandolfo, J. M. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Carbon, 4: 305-14(Oct. 1966). (GA-7046; CONF-650632-18).

Graphitic bodies that contain a fine dispersion of ZrC or MoC particles and that are hot-worked at temperatures high enough so that the carbide phase is in the liquid state were found to possess good density, impermeability, and strength. The carbide-bearing, bodies, originally prepared by molding, were deformed in compression at temperatures above the carbide–graphite eutectic temperature. The excess carbide was squeezed from the free surface of the body, which resulted in a predominantly graphitic body with properties approaching those of the pyrolytic graphites. The initial carbide content of 10 vol % was reduced to about 6 vol % when hot-worked to true strain levels of the order of 60 per cent. The initial stage of hot-working is rapid and corresponds to the effective elimination of open porosity and gas permeability. The second stage (beyond about 30 per cent strain) is slower, but the preferred orientation, thermal expansivity, and strength continue to change appreciably with increasing strain. The microstructure consisted of fine carbide particles, generally less than 5 $\mu$, distributed uniformly in an oriented graphite matrix whose structure differed from that of conventional molded or hot-worked graphites. Mo bearing bodies showed the highest strengths with moduli of rupture in excess of 20,000 psi. (auth)

**1932** UTILIZATION OF MICROSTRUCTURE IN PROCESSING. Pincus, Alexis G. (Univ. of California, Berkeley). 41p. (CONF-660619-4). ORAU. Gmelin, AED-CONF-66-204-10.

From 3rd International Materials Symposium on Ceramic Microstructure, Berkeley, Calif.

Microstructure examination, measurements, interpretation, and control provide indispensable tools for science-based processing of ceramics. During the complete cycle of processing, each of the features of multicrystalline ceramic microstructures needs to be controlled: pore phase, glassy phase, secondary crystalline phases predominant crystal phase, grain boundaries, and external surfaces. Knowledge of microstructures achieved during cold forming requires ability to prepare specimens from friable compacts. (auth)

**1933** RESISTANCE HOT-PRESSING OF URANIUM MONOCARBIDE. Chalder, G. H.; Berthiaume, L. C. 8p. (CONF-660606-44). ORAU. Gmelin, AED-CONF-66-203-99.

From American Nuclear Society Meeting, Denver.

UC pellets of 95 to 98% of theoretical density have been produced in less than 10 sec by direct resistance heating with pressure in vacuum. Variables were studied in the hot-pressing experiments. The microstructures of the pellets are described. The advantages of this method over other methods are listed. (D.L.C.)

**1934** IMPROVEMENTS IN OR RELATING TO CERAMIC MATERIALS. Munro, William (to United Kingdom Atomic Energy Authority). British Patent,1,045,072. Oct. 5, 1966. Filed June 17, 1963.

A method of interdispersing two ceramic materials is described. The particles of one ceramic material are mixed with a powdered second material containing a quantity of wax to coat the second material on the first. The coated particles are compacted and heated under reduced pressure to remove the wax. The dewaxed compact is then sintered. The method may be applied to production of dispersion fuels. (J.R.D.)

**1935** NUCLEAR REACTOR FUEL MATERIAL AND A METHOD OF PREPARING THE SAME. Nelson, Paul A.; Chasanov, Martin G. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,093. Nov. 22, 1966.

A method is described for preparing UN by forming metallic U into dense small-dimension bodies, nitriding the surface of the U bodies below the melting point of U, raising the temperature gradually past the melting point of U and nitriding the remainder of the U in the bodies at temperatures above the melting point of U. (AEC)

**1936** FUEL ELEMENT CONTAINING A MECHANICALLY COMPRESSIBLE MANDRIL. Lang, James E.; Proebstle, Richard A.; Wisnyi, Leonard G. (to U. S. Atomic Energy Commission). U. S. Patent 3,285,826. Nov. 15, 1966.

A patent relating to fuel elements for nuclear reactors is outlined including annular ceramic cores having central openings, metallic cladding surrounding the cores, and mechanically compressible mandrils disposed in central openings to prevent dislocated fragments of fuel from falling into the central openings while permitting the fuel to swell inwardly. (AEC)

**1937** IMPROVEMENTS IN OR RELATING TO COATING OF PARTICLES. Carley-Macauly, Kenneth Wallace; Williams, Gwilym Handel (to United Kingdom Atomic Energy Authority). British Patent 1,045,591. Oct. 12, 1966. Filed Apr. 25, 1963.

A method is described for coating particles with pyrolytic C by heating the particles in fluidized beds using mixed gas flows of hydrocarbons and $H_2$ for fluidization. Methane or acetylene may be used. The coating produced by this method improves the retention of gaseous fission products in UC fuel particles. (J.R.D.)

**1938** GRAPHITE WELDING. Mills, Loring E.; Boolen, Richard F. (to U. S. Atomic Energy Commission). U. S. Patent 3,288,879. Nov. 29, 1966.

A patent concerning welding of high-purity graphite parts is described. The parts are held together with a high initial pressure, and a large alternating current is briefly applied across the parts. Simultaneously the pressure between the parts is significantly increased, so that, in spite of a marked increase in area of the interface at which welding is to occur, the unit pressure between the parts is slightly greater than the initial unit pressure. (AEC)

## Properties Evaluations

*Refer also to abstract 2058.*

**1939** (BNWL-296(Pt.1)) ELECTRICAL CONDUCTIVITY OF $UO_2$. PART I. SINGLE CRYSTALS. Bates, J. L.; Hinman, C. A.; Kawada, T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Aug. 1966. Contract AT(45-1)-1830. 29p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

The electrical conductivity of near-stoichiometric single-crystal $UO_2$ ($UO_{2.001}$) was measured at room temperature to 3000°K. Below ~550°K, the curve of the log $\sigma$ versus $T^{-1}$ is linear having calculated activations energies at 0.17 to 0.20 eV. At 550 to 1250°K, a change in slope occurs which appears as a hump in the curve. With increasing temperature, the electrical conductivity increases rapidly above ~1250°K where the conduction changes from p-type to n-type. The activation energy increases with temperature from ~1.1 to ~1.6 eV with the best linear fit of ~1.5 eV. The high temperature conduction is assumed to be intrinsic; however a large difference exists between the thermal energy gap (3.0 eV) and that derived from optical absorption data (5.25 eV. (auth)

**1940** (KAPL-P-3174) SOME INPUT FUNCTIONS FOR COMPUTER DESCRIPTION OF FUEL PROPERTIES. PART II. MECHANICAL PROPERTIES. Lechliter, Gerald L.; Anderson, W. Kermit (Knolls Atomic Power Lab., Schenectady, N. Y.). [nd]. Contract W-31-109-eng-52. 8p. (CONF-661001-31). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 14th Conference on Remote Systems and Technology, Pittsburgh, Pa.

The analytic input functions for use in computer analysis of fuel mechanical properties are described. Representations are included for fuel viscosity, Young's modulus for Zircaloy-2, Young's modulus for fuel, and coefficient of thermal expansion for fuel. (J.R.D.)

**1941** (ORNL-TM-1595) AN EXPLANATION OF THE ANOMALOUS HEAT CAPACITY OF URANIUM DICARBIDE. Godfrey, T. G.; Leitnaker, J. M. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 15p. (CONF-660644-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 21st Annual Calorimetry Conference, Boulder, Colo.

Published enthalpy data on $UC_2$ indicate a heat capacity of 32 cal $mole^{-1}$ $deg^{-1}$ at 2000°K. Three lines of evidence indicate that the measurements are of acceptable accuracy. First, metallographic evidence indicates that a phase change takes place over a range of temperatures below approximately 2000°K. Second, high-temperature x-ray data indicate an unusual behavior in the lattice parameters of the $UC_2$ below 2000°K. Third, use of the enthalpy measurements with other published information completes a thermodynamic cycle in the U–C–O system. A non-zero $S^0_{0K}$ is shown to be a reasonable assumption. (auth)

**1942** INFRARED DIELECTRIC DISPERSION AND LATTICE DYNAMICS OF URANIUM DIOXIDE AND THORIUM DIOXIDE. Axe, J. D.; Petit, G. D. (IBM Watson Research Center, Yorktown Heights, N. Y.). Phys. Rev., 151: 676-80(Nov. 11, 1966).

Measurements at room temperature of the infrared reflectivity of single crystals of $ThO_2$ and $UO_2$ were carried out and analyzed by Kramers-Kronig relations. A single strong resonance is found in each case with $\omega_{TO} = 279(\pm 2)$ $cm^{-1}$, $\omega_{LO} = 568(\pm 4)$ $cm^{-1}$, $\epsilon_0 - n^2 = 15.5$ for $ThO_2$; $\omega_{TO} = 278(\pm 2)$ $cm^{-1}$, $\omega_{LO} = 556(\pm 4)$ $cm^{-1}$, $\epsilon_0 - n^2 = 17.7$ for $UO_2$ (TO = transverse optic; LO = longitudinal optic). The best classical dispersion-formula fit to the reflectivity yields the following parameters: for $ThO_2$, $\omega_0 = 282.7$ $cm^{-1}$, $\epsilon_0 - n^2 = 14.85$, $\bar{\gamma} = 16.2$ $cm^{-1}$; for $UO_2$, $\omega_0 = 283.2$ $cm^{-1}$, $\epsilon_0 - n^2 = 15.80$, $\bar{\gamma} = 18.5$ $cm^{-1}$. The low-frequency (0.3-Mc/sec) dielectric constant of $ThO_2$ was measured to be $18.9 \pm 0.4$. For $UO_2$ the mode frequencies are in excellent agreement with those obtained by neutron spectroscopy, and can be reconciled with existing infrared absorption data by taking into account particle-size corrections which can shift the polar mode frequency by a factor $\sim(\epsilon_0 + 2/n^2 +$

$2)^{\frac{1}{3}} \sim 1.8$ for small spherical samples. The above data are used to evaluate (Szigeti-type) effective charges ($Z'_{Th^{+4}} = 2.33$, $Z'_{U^{+4}} = 2.42$) and to discuss several approximate relations between the long-wave elastic and optical properties of the fluorite ($CaF_2$-type) lattice. Absorption bands were measured in the two-phonon-combination region in $UO_2$ and their assignment is discussed. (auth)

**1943** ELASTIC PROPERTIES OF ZIRCONIUM CARBIDE. Brown, H. L.; Kempter, C. P. (Los Alamos Scientific Lab., N. Mex.). Phys. Status Solidi, 18: K21-3(Nov. 1, 1966). (LA-DC-8206).

The elastic properties of a solid cylinder of ZrC made by hot pressing were measured. The elastic parameters at 23°C, adjusted to zero porosity, were found to be Young's modulus = $3.866 \times 10^{12}$ dyne/cm$^2$, shear modulus = $1.623 \times 10^{12}$ dyne/cm$^2$, bulk modulus = $2.087 \times 10^{12}$ dyne/cm$^2$, and Poisson's ratio = 0.191. The purity and stoichiometry of the material are described, and results are compared with previously published results for the carbides of Hf, Nb, Ta, and W. (A.G.W.)

**1944** COHERENT COATINGS OF REFRACTORY METALS. Senderoff, S.; Mellors, G. W. (Union Carbide Corp., Parma, Ohio). Science, 153: 1475-81(Sept. 23, 1966).

A general process was developed for the electrodeposition of eight of the nine refractory metals of groups IVB, VB, and VIB as dense coherent deposits. It consists essentially of the electrolysis of a solution of the refractory metal fluoride in a molten alkali-fluoride eutectic mixture, and deposits a coating, unalloyed with the substrate, by a process that obeys Faraday's law. Some evidence exists that the electrode-reaction mechanism by which coherent coatings are deposited from molten salts incorporates an irreversible metal-producing step. (auth)

**1945** METAL-CERAMIC ALLOY FOR WORK AT ELEVATED TEMPERATURES. Dergunova, V. S.; Komissarov, G. K.; Ermakova, M. P.; Kuznetsov, L. I.; Goldenberg, A. A. Vestn. Mashinostr., No. 6, 63-5(1966). (In Russian).

Several ternary alloys containing 40.8 to 60% TiC, 20 to 39.2% $B_4C$, and 20% SiC were compacted at 2100 to 2150°C under a pressure of 230 kg/cm$^2$, diffusion annealed at 1900°C for 12 hr in an argon atmosphere, cooled at the rate of 100°C/hr, and tested for oxidation resistance and thermal fatigue. Oxidation-resistance tests made on alloys oxidized in air at 900°C for 20 min, 1.5 hr, 3.5 hr, 10 hr, and 15 hr showed that the most intensive oxidation, accompanied with oxide film formation, occurs in the initial period of the exposure and practically ceases after 5-hr exposure. All tested alloys can be regarded as oxidation-resistant since their weight gain in 15-hr tests was only 4 to 6 mg/cm$^2$, which is 3.5 times lower than the weight gain of TiC under identical conditions of oxidation. The thermal fatigue resistance was evaluated from the number of quenches from 1200 and 2000°C sustained by alloy specimens before failure. In quenching from 1200°C, the investigated alloys sustained 40 thermal cycles without failure, which was double the number of thermal cycles sustained by TiC and 20 times as many as an alloy containing 85% SiC + 15% $B_4C$ sustained. Hence, titanium-, boron-, and silicon carbide-based alloys can be recommended as material suitable for making parts operating at high temperature under conditions of frequent temperature changes. (ATD)

**1946** EFFECT OF ALUMINUM OXIDE CONTENT AND DEFORMATION CONDITIONS ON THE RECRYSTALLIZATION OF SAP ALLOYS. Gorelik, S. S.; Gelman, A. A. (Inst. of Steel and Alloys, Moscow). Izv. Vyssh. Ucheb. Zaved., Tsvetn. Metal., No. 3, 134-7(1966). (In Russian).

SAP powders containing 4, 7.1, 8.9, or 13.3% aluminum oxide were hot compacted at 450°C with 94% total reduction, cold rolled with 50% reduction, and annealed to 500 to 700°C (hot-compacted specimens) or at 100 to 650°C (cold-rolled specimens). In the hot-compacted specimens with 4% aluminum oxide, no recrystallization occurred at temperatures up to 600°C, at which temperature the aluminum matrix began to melt. The recrystallization in cold-rolled specimens began at 450°C; at higher temperatures an intensive grain growth and a marked decrease of hardness was observed. In specimens containing more than 7% aluminum oxide, no recrystallization was observed up to the solidus temperature; annealing at 650°C for 24 hr produced no structural changes in cold-rolled specimens with 8.9% aluminum oxide. However, the hardness and strength of specimens containing more than 7% aluminum oxide dropped after annealing at 550°C or over, which was explained by crack formation. With increasing aluminum oxide the susceptibility to crack formation increased. Increases in the content of aluminum oxide also weakened the texture indication in the diffraction patterns of hot-compacted specimens. This effect was not observed in cold-rolled specimens. (ATD)

**1947** STRENGTH AND FRACTURE OF DENSE MgO. Rice, Roy W. (Boeing Co., Seattle). 16p. (CONF-660619-5). ORAU. Gmelin, AED-CONF-66-204-11.

From 3rd International Materials Symposium on Ceramic Microstructure, Berkeley, Calif.

A study was made of the strength-grain size relationships for hot-pressed and hot-extruded MgO. Volatile-producing impurities trapped in hot-pressed MgO result in lower strengths, although firing can minimize this at the expense of some potential strength. Both types of MgO obey the Petch relationship, although hot-extruded MgO is stronger due to texturing. It is concluded that dislocation phenomena is a critical factor in the strength and fracture of polycrystalline MgO. The case of $Al_2O_3$ is also discussed briefly. (D.L.C.)

**1948** PHYSICO-CHEMICAL PROPERTIES OF CARBIDE FUEL FOR THERMIONICS. Yang, L.; Hudson, R. G.; Carpenter, F. D. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). 23p. (CONF-661003-11). ORAU.

From AIME Nuclear Metallurgy Symposium on High Temperature Nuclear Fuels, Delavan, Wis.

Certain physicochemical properties of uranium zirconium monocarbide that are pertinent to thermionic applications were studied. Langmuir rates of vaporization of UC–ZrC were studied as a function of composition and density in the range from 1700 to 2000°C. For stoichiometric samples, the rates of vaporization were relatively insensitive to density and the degree of open porosity of the sample. At 1800°C, the rates of vaporization were $3 \times 10^{-8}$ and $3 \times 10^{-9}$ g/cm$^2$/sec for 90 UC–10 ZrC and 30 UC–70 ZrC, respectively. Compatibility of UC–ZrC with refractory metals at 1400 to 2000°C was studied, and metallographic and electron microprobe examinations of the diffusion couples showed that tungsten was one of the most promising cladding materials for use with UC–ZrC fuels in thermionic application. Results of studies of electron emission properties of tungsten-clad UC–ZrC at 1400 to 2000°C in vacuum for 1000 hours indicated that stable emission characteristics could be maintained if the carbides were slightly (~ a few mole %) carbon rich. For 90 UC–10 ZrC clad with 20-mil-thick, vapor-deposited tungsten, such stable emission characteristics could be maintained for at least 1000 hours even at 1900°C. These results indicate that tungsten-clad UC–ZrC fuels are promising materials for thermionic applications. (auth)

## *Structure and Phase Studies*

*Refer also to abstracts 1908 and 2864.*

**1949** (CEA-R-2972) CONTRIBUTION A L'ETUDE DES TEXTURES DE BARREAUX D'URANIUM MIS EN FORME PAR FRITTAGE-EXTRUSION ET LEURS CONSEQUENCES SUR LE COMPORTEMENT AU CYCLAGE THERMIQUE. (Contribution to the Study of the Textures of Uranium Rods Prepared by Sintering-Extrusion, and Their Consequences on the Thermal Cycling Behavior). Peix, Jose (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1966. 73p. Dep. mn. (In French)

Thesis. Submitted to Paris Univ., France.

U rods prepared by sintering-extrusion in the $\alpha$ or $\beta$ phase using slightly oxidized powders were subjected to thermal cycling. At the same time, dilatometric and x-ray techniques made it possible to determine the structures produced in these materials during their fabrication. A relationship is proposed linking the texture to the increase in length on thermal cycling. Sintered-extruded rods in the $\beta$ phase at a low density with large grain-size and no preferential texture were studied along with sintered-extruded rods in the $\alpha$ phase at high density with fine grain and pronounced preferential texture. After 1000 thermal cycles between 20 and 550°C, the length increases were 2% for a U sintered-extruded in the $\beta$ phase and between 14 and 56% according to the extrusion ratio for the U sintered-extruded in the $\alpha$ phase. In the case of rods sintered-extruded in the $\alpha$ phase, determination of the pole figure using the Schulz reflection method showed the existence of two preferential orientations parallel to the direction of extrusion: one close to [100], and the other close to [110]. By dilatometry it was then possible to measure quantitatively the proportion of each constituent in the overall texture and to show that an increase in the percentage of [100] occurs with increasing amounts of cold-working. The increases in length owing to thermal cycling are connected to the percentage amounts of each component. It seems that the increases in length diminish as the percentage of [100] increases. On the other hand the behavior of materials containing large amount of [110] is still far from clear. (auth)

**1950** (MCW-1501) SOME OBSERVATIONS ON THE ELECTRON METALLOGRAPHY OF URANIUM. Kloepper, H. C. Jr. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.).

Aug. 1, 1966. Contract 14-108-eng-8. 63p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Metallographic techniques are described that are necessary in the preparation of thin-foil specimens of U metal suitable for study at high magnification with the transmission electron microscope. Also discussed are the relations between structure revealed in electron microscopy and x-ray-diffraction data generated from the same area by the electron beam. Application of these techniques to three beta-quenched, alpha-annealed U–Si alloys disclosed that precipitation of $U_3Si$ did not occur within reasonable annealing times at 500°C or less but that precipitation readily took place at dislocation sites when annealed at 600°C, the number and size of particles increasing with annealing time. The $U_3Si$ particles were needle-shaped with a preferred orientation to the U matrix. Other studies of structures of a U–Si alloy after tensile testing indicated that the deformation at room temperature was by twinning whereas at 500°C the metallic flow was mainly by slip. (auth)

**1951** (MCW-1502) PHASE STUDIES OF THE URANIUM–IRON–SILICON TERNARY SYSTEM WITH THE ELECTRON MICROPROBE. Schierding, R. G.; Fergason, L. A. (Mallinckrodt Chemical Works, Weldon Spring, Mo. (Uranium Div.). Aug. 1, 1966. Contract W-14-108-eng-8. 17p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The solubility limits of Fe and Si in the U allotropes and in the intermetallic phases $U_6Fe$ and $U_3Si$ were determined by electron microprobe analysis. The allotropic transformation temperatures were determined by differential thermal analysis. The U-rich portion of the U–Fe binary phase diagram is presented along with isothermal sections of the U-rich corner of the U–Fe–Si ternary system. (auth)

**1952** (CEA-tr-R-1702) ETUDE DE CERTAINS OXYDES D'URANIUM. (Studies of Certain Uranium Oxides). Kovba, L. M.; Kuz'micheva, E. U.; Ippolitova, E. A. Translated into French from Vestn. Moskov. Univ., Ser. II: Khim., 19: No. 3, 34-6(1964). 8p. Dep. mn. JCL $1.10 fs, $0.80 mf.

The composition of phases of anneal products of $\beta$-$U_3O_7$ and of mixtures of $UO_{2.00}$ with $U_3O_8$ with variable ratios was studied. Results showed that the black oxide reacts with uranium dioxide at 300 to 400°C, producing $U_4O_9$ and not the tetragonal oxide. To determine the possibility of the formation of tetragonal oxides during the reduction of black oxide and uranium trioxide, the tetragonal oxides were calculated in a hydrogen current at 250 to 400°C. A cubic phase with fluorine lattice was obtained in all cases. The results of the phase analysis and the lattice parameters are tabulated. In the study of the reaction of black oxide with sulfuric acid, the formation of a new oxide with a hexagonal lattice was detected. Its composition lies between $UO_{2.48}$ and $UO_{2.54}$. The hexagonal oxides are also formed as a result of the thermal decomposition of amorphous uranium trioxide. The parameters of this phase are given. (J.S.R.)

**1953** LIMITED SOLID SOLUTIONS OF URANIUM AND THORIUM DICARBIDES. Langer, S.; Gantzel, P. K.; Baldwin, N. L. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Inorg. Chem., 5: 2031-40(Nov. 1966).

The quasi-binary system $ThC_2$–$UC_2$ was studied across the entire composition range by thermal analysis, isothermal annealing experiments from 1600 to 2100°C, and room-temperature and high-temperature x-ray diffraction. The system exhibited complete miscibility at elevated temperatures with alloys having cubic symmetry. At lower temperatures, a miscibility gap about 7 mole % wide existed in the range of 60 to 67 mole % $UC_2$. In this region two nonisomorphic tetragonal phases coexisted. One of these phases was a $UC_2$-type tetragonal phase with c/a = 1.653. The other phase was a $ThC_2$-type tetragonal phase with c/a = 1.275. The transitions from cubic to tetragonal were diffusionless and unquenchable. A tentative phase diagram is proposed, and the coexisting phases are discussed in terms of the high-temperature structures of the pure materials. (auth)

## *Radiation Effects*

*Refer also to abstracts 1923, 2291, 2294, and 2331.*

**1954** (AD-641164) RADIATION EFFECTS ON INSULATED GATE FIELD EFFECT (MOS) INTEGRATED CIRCUITS. Quarterly Report No. 4, April 1–June 30, 1966. Long, D. M. (Martin Co., Baltimore, Md.). Oct. 1966. Contract DA-28-043-AMC-01520(E). 85p. (MND-3264-4; ECOM-01520-4). CFSTI $3.00 cy, $0.75 mn.

Activities in a program to determine the mechanism and extent of the transient and permanent effects of nuclear radiation on insulated-gate field effect metal-oxide-semiconductor (MOS) integrated circuits are reported. The results of the past year's investigation of transient response phenomena in custom-built and commercial MOS transistors and commercial MOS integrated circuits are discussed. It was found that the transient gate current produced in MOS transistors by pulsed ionizing radiation is composed of current leakage from the gate lead to the package through the ionized encapsulated gas, and photovoltaic displacement current resulting from the motion of induced carriers in the transverse electric field beneath the gate oxide. The mechanisms produce a larger response for n-depletion transistors than for p-enhancement transistors. Mechanisms of generally lesser importance include photocurrents of protective gate diodes, gate-drain interaction leakage currents, and variations in gate current due to irradiation history. Charge scattering from the device leads is small, and ionization-induced leakage through the gate oxide is negligible. The components of transient drain current are the photocurrent of the drain-substrate p-n junction, the drain current produced by the $g_m$ amplification of threshold voltage changes (occurs with or without $R_g = 0$), and secondary drain current produced by the $g_m$ amplification of gate voltage changes (occurs only for large $R_g$ values). Transient changes in threshold voltage are common for n-depletion devices, and relatively uncommon for p-enhancement devices. Devices of a given type can differ widely in the magnitude of $\Delta V_T$. MOS integrated circuits which are presently available have transient failure thresholds in the range of 1 to 100r for radiation pulse widths less than the resistance-current (RC) time constants of the circuits (typically $\mu$ sec). Both substrate currents, which produce turn-on, and secondary drain currents, which produce turn-off, are instrumental in causing failure in microcircuits. Latch-up or long term recovery processes (greater than a few $\mu$ sec) were not observed on any of the circuits tested. It appears that the sensitivity of MOS integrated circuits to transient ionizing radiation could be improved by dielectric substrate isolation, and use of evacuated (rather than gasfilled) packages. (auth)

**1955** (AECL-2601) INITIAL RESULTS OF THE IN-REACTOR COMPATIBILITY OF $UO_2$ WITH REFRACTORY METALS, OXIDES, AND GRAPHITE. MacDonald, R. D. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). July 1966. 20p. (EXP-NRX-23503). Dep. mn. AECL $0.50.

Zircaloy-2-clad fuel elements were irradiated for one reactor cycle to investigate high temperature (up to 2300°C) compatibility of $UO_2$ with discs of W, Re, Mo, Ta, Nb, $Al_2O_3$ and $ThO_2$ and with graphite rings. Two elements were destructively examined. The metal discs had altered the temperature profile of the $UO_2$ pellets, reducing the metal-$UO_2$ interface temperatures to about 1550°C compared with 2280°C at the middle of the pellet. No reaction between the discs and fuel was observed; however, most of the disc materials had recrystallized and most metal discs exhibited plastic flow. The two intact elements will be re-irradiated at higher heat ratings to increase the probability of a reaction between the $UO_2$ and disc materials. (auth)

**1956** (CONF-660606-53) POST-IRRADIATION EXAMINATION OF 5 w/o $PuO_2$–$UO_2$ FUELS. Ross, W. J.; Puechl, K. H.; Caldwell, C. S.; Miles, J.; Shipko, F.; Judd, W. C. (Nuclear Materials and Equipment Corp., Apollo, Pa.). [1966]. Contract AT (30-1)-3432. 33p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From American Nuclear Society Meeting, Denver, Colo.

Capsules containing stainless steel-clad fuel elements were irradiated to 10,000 and 20,000 MWd/t. Samples were prepared by precipitation from liquid nitrate solutions and by mechanical blending of $PuO_2$ and $UO_2$. Data on preparation methods are included along with photomicrographs and autoradiographs used in observations of performance of pellets prepared by precipitation and mechanical blending. (J.R.D.)

**1957** (GA-6493) DESCRIPTION AND RESULTS OF THE TARGET P8 COATED PARTICLE IRRADIATION CAPSULE. Luby, C. S. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). June 22, 1966. Contract AT(04-3)-167. 44p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Twelve types of coated fuel particles were irradiated to 11 to 13% burnup at 900 to 1500°C. Post-irradiation examination indicated that Buffer-Isotropic coatings appear better than Triplex coatings in radiation stability, and coated oxides appear slightly better than coated carbides. Pre-irradiation thermal treatment had no effect on the radiation stability of coated oxide particles, but a slight detrimental effect on coated carbides. The relatively high failure rate of many particles in this test was attributed in major part to a low coating-thickness to fuel-particle-dia ratio (0.25). (auth)

**1958** (GA-7120) ADVANCED BeO FUEL STUDIES. Meyer, R. A.; Lofftus, F. H.; Goodjohn, A. J. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Sept. 23, 1966. Contract AT(04-3)-187. 22p. (CONF-661003-7). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From AIME Nuclear Metallurgy Symposium on High Temperature Nuclear Fuels, Delavan, Wis.

A program was undertaken to investigate various methods of fabricating pellets of BeO containing up to 25 Vol % of U or U–Th fuel particles so the fuel would have good fission product retention characteristics up to 1650°C and linear heating rates up to 300 W/cm (≅20,000 BTU/hrft). The fuel pellets were fabricated by isostatically cold pressing and sintering or by hot pressing methods. In some cases the BeO matrix densities were in excess of 99.4% of theoretical and the beginning of life fractional release values for Xe and Kr were as low as $7 \times 10^{-8}$ after 1 hr. The irradiation characteristics of these fuels and factors affecting the fission product retention characteristics are discussed. (auth)

**1959** (N-66-22820) STUDY TO INVESTIGATE THE EFFECTS OF IONIZING RADIATION ON TRANSISTOR SURFACES. Quarterly Report No. 1, July 1–September 30, 1965. Nelson, David L. (Bendix Corp., Southfield, Mich. Research Labs. Div.). Oct. 26, 1965. Contract NAS8-20135. 21p. (NASA-CR-71645). CFSTI $1.00 cy, $0.50 mn.

A program to investigate the effects of ionizing radiation on transistor surfaces, using 150-kV x rays, to determine the physical mechanisms involved, and to formulate screening techniques which will enable categorizing devices as to their surface stability in ionizing radiation is described. During this period x ray facilities were prepared for testing, fixtures were constructed, and instrumentation was assembled in preparation for radiation testing of Fairchild 2N1613 transistors. Facilities, fixtures, and instrumentation were checked out with a cursory test intended to evaluate capabilities and limitations of the test system. Transistors were procured and initial measurements were performed in preparation for the first test which is scheduled to begin early in the second quarter. (auth)

**1960** (SGAE-CH-36/1966) UNTERSUCHUNG UEBER DIE SPALTPRODUKTVERTEILUNG IN DER BESCHICHTUNG VON BRENNSTOFFTEILCHEN FUER HOCHTEMPERATURREAKTOREN. II. TEIL. (Investigation of Fission Product Diffusion in Coatings of Fuel Elements for High Temperature Reactors. Part II). Szterk, L.; Bildstein, H. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf). 1966. 21p. Dep. mn.

The diffusion of fission products in the coating of Pyrolytic carbon-coated fuel particles for high temperature reactors was investigated. The coating of irradiated particles was removed stepwise chemically and the resulting etching solutions analyzed by gamma spectrometry. The experiments were performed on particles with sintered and melted $(U,Th)C_2$–kernels. The release of fission products as Ba/La, Zr, Ru, and Cs is described. (auth)

**1961** (UNC-5136) EXPERIMENT DESCRIPTION AND HAZARDS ANALYSIS FOR CAPSULES UNC 78, 79, AND 80. Cihi, J.; Rosh, D. (United Nuclear Corp., White Plains, N. Y. Development Div.). Oct. 22, 1965. Contract AT(30-1)-3415. 87p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Procedures for use in determining the operating limits of mixed UC-PuC fuel for fast breeder reactors are described. Plans are outlined for irradiation of full-length mixed PuC–UC rods and subassemblies at 20 to 50 kW/ft. Burnups are planned to reach 100,000 MWd/t. Factors affecting safety are discussed along with eddy current testing methods for irradiation capsules. (J.R.D.)

**1962** (WAPD-TM-574) IRRADIATION PERFORMANCE CAPABILITIES OF OXIDE FUEL RODS X-1-u TEST OF TWO 100-INCH LONG HIGHLY RATED ANNULAR $ZrO_2 + UO_2$ FUEL RODS. Rubin, B.; Daniel, R. C.; Lynam, L.; McCauley, J. E.; Meieran, H. B. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1966. Contract AT(11-1)-Gen-14. 203p. Dep. mn. CFSTI $6.00 cy, $1.25 mn.

The in-pile performance capabilities of a 100-in.-long, segmented oxide fuel rod were determined. The rod contained 99% T. D. annular pellets of $ZrO_2$ + 55.4 wt % $U^EO_2$, 99% T. D. annular pellets of $ZrO_2$ + 46.7 wt % $U^EO_2$, and 81% T. D. solid pellets of $ThO_2$ + 14.9 wt % $UO_2$ in a Zircaloy-4 sheath fabricated by 78% cold working followed by four hours at 950°F stress relief anneal. The rod failed after $10 \times 10^{20}$ fissions/cc at 685,000 Btu/hr-ft$^3$ by localized oxidation and spalling of the outside cladding surface due to steam blanketing. This represented one-third of the design burnup. The cause of the burnout is tentatively attributed to water channel reduction caused by dimensional instability of the tubing and fuel plasticity due to operation at high temperature. The annular fuel pellet was shown to exhibit swelling into the center hole. Severe embrittlement of the sheath occurred after failure due to massive internal hydriding at localized positions. Gamma scanning and neutron radiography were shown to be valuable experimental tools in nondestructive evaluation of rod performance. Measurements of fuel conductivities were made using microstructural markers in the fuel. (auth)

**1963** (WAPD-TM-583) COMPARISONS WITH EXPERIMENT OF CALCULATED DIMENSIONAL CHANGES AND FAILURE ANALYSIS OF IRRADIATED BULK OXIDE FUEL TEST RODS USING THE CYGRO-1 COMPUTER PROGRAM. Duncombe, E.; Meyer, J. E.; Coffman, W. A. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1966. Contract AT(11-1)-Gen-14. 93p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Analysis techniques were developed and incorporated into a digital computer program (CYGRO-1) to estimate the temperature, stresses, deformation, and failure characteristics of bulk-oxide nuclear reactor fuel rods during life. Comparisons are made between CYGRO calculations and results from irradiation tests of a series of Zircaloy bulk-oxide rods. Methods of incorporating material property information for a variety of physical processes which occur in the fuel are presented in detail. (auth)

**1964** (ORNL-tr-1347) MEASUREMENT OF DIMENSIONAL CHANGES OF PYROLYTIC CARBONS INDUCED BY RADIATION (GRAPHITE RIG 3, BR 2 MOL/BELGIUM). Delle, W. (Kernforschungsanlage, Juelich (West Germany)). Translated for Oak Ridge National Lab., Tenn., from Report No. 4. 15p. Dep. mn. JCL $1.60 fs, $0.80 mf.

Descriptions of measurement methods including those using microscopes are presented. A review of the measuring programs at ORNL and at the Nukem company is presented. Results of investigations indicate that unsupported samples of the pyrolytic C shrink and crack more than those laminated on graphite for support. Data are included on shrinkage of ORNL and Nukem samples. (J.R.D.)

**1965** EFFECT OF THE FORMATION OF VACANCY LINES ON THE KINETICS OF IRRADIATION DAMAGE IN GRAPHITE SINGLE CRYSTALS. **Horner, P.; Williamson, G. K. (Berkeley Nuclear Labs., Eng.). Carbon, 4: 353-63(Oct. 1966).**

The concept of collapsed lines of vacancies formed by the random agglomeration of radioinduced point defects was introduced to explain certain observed irradiation properties of graphite. This concept is examined theoretically in detail and a kinetic irradiation damage model is developed. This model, besides accounting for the random formation of the vacancy complexes, makes allowance for the nucleation of interstitial clusters and their subsequent growth and for the annihilation of interstitials at vacancies. Analysis of the differential equations of the model gives estimates of the density of the various defects and, by making assumptions of the role played by these defects in producing the macroscopic properties, the model can be compared with observed experimental results. The model successfully predicts the concept of "break-away" as observed in the crystal growth data and, allowing for the inaccuracies inherent in the assumptions made and in the calculation of the various model parameters, the results predicted are in good agreement with the experimentally observed data on growth and total stored energy. The model also predicts the dynamic nucleation of the "hidden population" of interstitial defects. (auth)

**1966** RADIATION-INDUCED DIMENSIONAL CHANGES IN PYROLYTIC CARBONS DEPOSITED IN A FLUIDIZED BED. **Bokros, J. C.; Price, R. J. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Carbon, 4: 441-54(Oct. 1966). (GA–6736).**

A range of pyrolytic C structures representative of those used as coatings for nuclear fuel particles was irradiated at temperatures between 540 and 1060°C to fast neutron exposures of 1.5 to $2.4 \times 10^{21}$ nvt (E > 0.18 MeV). Changes in linear dimensions, density, and crystallite size were measured. The data showed that radioinduced dimensional changes in pyrolytic C depend sensitively on their structure. At ~1000°C the dimensional changes depended primarily on the degree of preferred orientation with a secondary dependence on the density of the C. The changes calculated for the crystallites were independent of the crystallite height, $L_c$, in the range 30 to 145 Å but the changes are less for larger $L_c$ values. At ~600°C the dimensional changes depended on the $L_c$, density, and degree of preferred orientation. At this temperature the calculated crystallite changes were very sensitive to variations in $L_c$ in the range 30 to 200 Å. At all temperatures the irradiation caused the carbons to densify. The irradiation tended to increase the $L_c$ value of carbons with initially small $L_c$ values and decrease those of carbons with initially high $L_c$ values. The observed radioinduced changes are discussed in terms of current theories of irradiation damage in C and graphite. (auth)

**1967** RADIATION EFFECTS IN GRAPHITE. Wittels, M. C. Nucl. Safety, 7: 318-23(Spring 1966).

A brief review is given of a number of theoretical and experimental studies on graphite. The investigations described include theoretical models of defect kinetics, stored-energy release spectra, molecular recombination hypotheses, and flux-level and flux-

spectrum effects. The experimental studies described comprise the direct observation of defects in graphite single crystals, fast-neutron and charged-particle irradiations, and associated radiation-induced changes. Reactor graphite investigations are given for hardness measurements in the Marcoule (G1) reactor, cyclic annealing behavior of dimensional changes in the Brookhaven Graphite Research Reactor, and general effects of radiation in Hanford reactors. The review considers efforts of a purely research nature as well as actual reactor safety applications. (auth)

## Plastics and Other Materials

*Refer also to abstracts 1672, 1923, 2291, and 2310.*

**1968** (AD-628691) A SUMMARY OF SURFACE EFFECTS OF RADIATION ON SEMICONDUCTOR DEVICES. Mitchell, J. P.; Wilson, D. K. (Bell Telephone Labs., Inc., New York). Dec. 1, 1965. Contract AF19(628)-4157. 79p. (AFCRL-65-898). CFSTI $3.00 cy, $0.75 mn.

A review of surface physics is given as background for a discussion on the role of surfaces in the behavior of semiconductor devices. The effects of channels and surface generation-recombination on p-n junctions and transistor characteristics are discussed. The observed effects of ionizing radiation on nonpassivated, gas-filled transistors are interpreted in terms of a model in which ions formed in the gas ambient deposit charge on the device surface. The resultant surface charge buildup creates channels on the device surface which cause a decrease in $h_{FE}$ and increase in $I_{CBO}$. Saturation, recovery, and the effects of dose rate and bias are also discussed. Degradation of planar passivated transistors and other devices employing $SiO_2$ layers due to radiation is similar to that observed for nonpassivated devices. Surface charge buildup affects the device surface and leads to degradation. The bulk of experimental evidence points to accumulation of positive charge at the $SiO_2$–Si interface as the cause of degradation. Several possible means of charge buildup at the interface are discussed. However, the process responsible has not, as yet, been identified. The direction of future experiments is discussed, particularly of those experiments which may yield information about the part played by radiation in positive charge accumulation at the $SiO_2$–Si interface. (auth)

**1969** (AD-632716) EFFECT OF TRANSISTOR DESIGN PARAMETERS ON RADIATION RESPONSE (SURFACE EFFECTS) Final Report No. 4, December 15, 1964–December 15, 1965. Gallagher, B. D.; Honnold, V. R.; Mazenko, J. J. (Hughes Aircraft Co., Newport Beach, Calif. Microelectronics Div.). Apr. 1966. Contract DA-28-043-AMC-00418(E). 64p. (ECOM-00418(E)). CFSTI $3.00 cy, $0.75 mn.

Relations in electronic devices between various transistor surface conditions and transient leakage currents ($\Delta I_{CBO}$) due to radiation exposure were studied. These studies were made by utilizing 2N708 type transistors with various surface treatments, and similarly treated groups of n-type Si bars. The primary surfaces studied were (1) oxidized, (2) sandblasted, etched, and mechanically polished. An analytical model describing the predominate mechanism of surface radiation effects was developed. This relation was tested against the experimental data and order of magnitude agreement was found. It was concluded that at a given value of surface recombination velocity, the radiation induced response, $\Delta I_{CBO}$, in a device is less for smaller values of minority carrier lifetime. Thus, no characteristic compromise is necessary to achieve maximum device radiation resistance. It was found that an increase in radiation resistance can be achieved in a device by increasing surface recombination velocity. However, the improvement in radiation resistance is obtained at the cost of decreased transistor gain and increased leakage currents. (auth)

**1970** (AD-633307) LOW TEMPERATURE NEUTRON IRRADIATION FACILITY FOR STUDIES IN HOT-ATOM CHEMISTRY AND RADIATION DAMAGE STUDIES IN MATERIALS. Technical Report. Hobbs, John R.; Owens, Charles W. (Army Materials Research Agency, Watertown, Mass. Materials Research Div.). Feb. 1966. 25p. (AMRA-TR-66-05). CFSTI $1.00 cy, $0.50 mn.

A low temperature neutron irradiation facility was constructed and tested for the AMRA research reactor. A description of the apparatus is given and results obtained for neutron irradiation of mixed crystals of $NaBrO_3$–$NaClO_3$ at −80°C are presented. (auth)

**1971** (AD-634292) RADIATION EFFECTS IN FLUOROLUBE. Downey, M. J. (Royal Aircraft Establishment, Farnborough (England)). Feb. 1966. 16p. (TR-66024). CFSTI $1.00 cy, $0.50 mn.

A program of work undertaken to examine the effects of gamma radiation on Fluorolube is described. The changes in viscosity and the amount of gas evolved, under certain conditions, as a result of doses of 10, 40, 100, 150 and 200 megarads, are given. (auth)

**1972** (AD-634488) INVESTIGATION OF TRANSIENT RADIATION DAMAGE IN SEMICONDUCTOR MATERIALS. Quarterly Progress Report No. 2, January 1, Mar. 31, 1966. Corelli, John C.; Frederickson, A. Robb; Westhead, James W. (Rensselaer Polytechnic Inst., Troy, N. Y.). June 1966. Contract DA-28-043-AMC-01788(E). 25p. (ECOM-01788-2). CFSTI $1.00 cy, $0.50 mn.

Transient radiation effects induced in Si irradiated at 122°K and 300°K by pulses of 48 MeV electrons were studied using the transient response of resistivity and Hall effect voltages as the measuring probes. Results are given for one ohm-cm P-doped n-type Si and a 100 ohm-cm B-doped p-type sample. In the case of one ohm-cm Si the results clearly show the actual buildup of excess electrons produced by ionization during the time the electron pulse is irradiating the sample. Moreover, the shape of the pulse during buildup is independent of temperature so long as the electron beam pulse is kept constant. Dependence of the number of injected excess carriers on the ionization intensity (total integrated electron flux in the pulse) was found to be linear up to excess carrier concentrations of $10^{17}/cm^3$. The lifetime is found to increase linearly with injection implying that the recombination may be dominated by one defect energy level. The significant "damage mechanism" can be understood by considering only the transient ionization effects, since atomic displacements effects are small and insignificant. (auth)

**1973** (AD-634493) LABORATORY TESTING AND THEORETICAL STUDIES IN TRANSIENT RADIATION EFFECTS ON MICROELECTRONICS. Report for September 1, 1964–July 31, 1965. Grannemann, W. W. (New Mexico Univ., Albuquerque. Bureau of Engineering Research). May 1966. Contract AF 29 (601)-6637. 150p. (AFWL-TR-65-175). CFSTI $4.00 cy, $1.00 mn.

A series of experimental studies were conducted on transistor elements suitable for microcircuits. A relationship of transient radiation effects to active volume and other parameters was made. The experimental and theoretical method developed offers a way of obtaining minority carrier lifetimes, depletion layer width, junction area, diffusion length, and active volume when the absorbed dose and the ionization efficiency are known in the transistor element of a microcircuit. Conversely, given the above parameters it is possible to determine the primary photocurrent of the microcircuit junction under a variety of radiation conditions. It was shown that the fundamental Boltzmann equation describing charge transport in semiconductors can be used to modify the usual continuity equation to obtain a more accurate circuit model for transistor elements in microcircuits. The oxide-isolated microcircuits were tested and compared with the usual backbiased isolation junction diode type. (auth)

**1974** (N-66-23592) A STUDY OF THE EFFECTS OF SPACE RADIATION ON SILICON INTEGRATED MICROCIRCUITS. VOLUME I. Final Report, June 26, 1964–September 26, 1965. (Battelle Memorial Inst., Columbus, Ohio). Contract NAS5-3985. 596p. (NASA-CR-74128). CFSTI $8.96 cy, $2.75 mn.

Monolithic digital microcircuit types, representing prevalent logic configurations, functions, and construction methods, were exposed to 3-MeV electron environments until failure. The electron fluence at which failure first occurred varied from the low value of $7 \times 10^{14} e/cm^2$ to the high of $1.8 \times 10^{16} e/cm^2$. Each microcircuit type was represented by four test groups. One was maintained as a control and the others were irradiated under the nonenergized condition, the dynamic ac operation, and the worst-case static operation. Among the conclusions reached are: (1) The radiation resistance of Si-integrated circuits is determined by the gain stability of the elements with respect to cumulative exposure and the circuit tolerance with respect to gain degradation. (2) No class of microcircuits is inherently superior, but faster transistors required greater electron fluence for failure. (3) An excessive $V_0$ output voltage is the predominant mode of microcircuit failure. Individual approximate relationships between the microcircuit parameters and the radiation were established. (auth)

**1975** (N-66-23826) STUDY TO INVESTIGATE THE EFFECTS OF IONIZING RADIATION ON TRANSISTOR SURFACES. Quarterly Report No. 2, October 1–December 31, 1965. Nelson, David L. (Bendix Corp., Southfield, Mich. Research Labs. Div.). Feb. 11, 1966. Contract NAS8-20135. 30p. (NASA-CR-71888). CFSTI $2.00 cy, $0.50 mn.

Four tests were conducted on n-p-n planar transistors to determine the effects of electrical bias during irradiation on radiation damage, and various measurement conditions, on the magnitude of degradation. It was found that low current measurements

sustained much higher gain degradation. Gain damage components identified included channel current, surface space charge recombination-generation current, and damage effective only at high currents. Annealing cycles were investigated which were combinations of temperature, electrical bias, and x ray irradiation; and a temperature recovery cycle was defined which completely removes x-ray-induced damage. Occasional failure of some temperature-recovered devices to repeat their initial damage buildup curves is attributed to incomplete redistribution of charge species in the passivating oxide. (M.W.R.)

**1976** EFFECT OF THE EARTH'S RADIATION BELTS ON AN OPTICAL SYSTEM. Wolff, C. (Goddard Space Flight Center, Greenbelt, Md.). Appl. Opt., 5: 1838-42(Nov. 1966).

A photoelectric optical imaging system has survived one year in the earth's radiation belts with no measurable (<20%) change in sensitivity. The system passes through all of the radiation belts twice every 64 hr, and experiences a noise level equivalent to 400 photons/sec when in their most intense regions. While this noise is far less than that of other photoelectric systems operating in the belts because of the small effective area of the photocathode, the noise per unit cathode area is $1.3 \times 10^5$ photons/sec-cm$^2$, and is similar to the best of the other systems. The number and energy distribution of incident particles is calculated and then combined with shielding estimates to give the total energy absorbed in the optical elements. Radiation damage reports in the literature are shown to be consistent with the lack of a sensitivity change in this orbiting optical system. The effects of particle radiation on optical systems in general are briefly summarized, with emphasis on recent work of others. (auth)

# PHYSICS (GENERAL)

## Astrophysics

*Refer also to abstracts 1467, 1608, 2053, 2344, and 2443.*

**1977** DETERMINATION OF THE ELECTRON DENSITY OF THE SUN'S CORONA. Widmer, Georg. Vierteljahresschr. Naturforsch. Ges. Zuerich, 108: 105-39(Mar. 1963). (In German).

Previous methods are reviewed and a new method was developed for the determination of electron density distributions in a rotationally symmetric solar corona. Under this assumption, taking into consideration anisotropic scattering and limb darkening, the integral equations are derived for each heliographic latitude and for different degrees of polarization. The equations themselves, as their analytically feasible inverse transformations, are of the Volterra type. Computations of densities are worked out using the explicit formula by numerical integrations over brightness distributions on different sections perpendicular to the solar axis. An ALGOL program was written to be used by a computer, which allows future calculations for any distribution of measured points and for each degree of polarization. Density distributions are given for the minimum corona of 1954 and represented in an isoelectron density map. Attempts are made to assess the validity of these results. (BBB)

**1978** SOME PROPERTIES OF SOLAR NOISE STORMS AT 1.5 m. Yurovskaya, L. I. Izv. Krymsk. Astrofiz. Observ., 32: 76-83(1964). (In Russian).

Ten noise storms were studied. Their duration, variations of the median flux and bursts, and the spot groups which can be connected with them were considered. The directivity diagrams for the median flux and bursts were determined taking into account absorption, refraction, and the presence of nonuniformities in the corona. It is shown that the directivity diagrams are broader for bursts than for meridian fluxes by a factor of 1.5 to 2. (auth)

**1979** ISOTOPIC MEASUREMENT OF CHROMIUM INDUCED BY COSMIC RAYS IN IRON METEORITES. Shima, Masako; Honda, Masatake (Tokyo Univ.). Shitsuryo Bunseki, 14: No. 1, 23-4(Mar. 1966).

Stable chromium nuclides produced by cosmic rays were measured by the surface ionization method applied with a chromium fraction extracted from several iron meteorites. A solid source mass spectrometer, MS-5, manufactured by AEI, England, was used for the determination of the isotopic ratios. It was found to be useful to apply the single filament technique using a tungsten ribbon. Repeated experiments using a microgram quantity of reagent chromium gave satisfactory small deviation throughout the course of this work which extended more than one year. The result with the reagent was in good agreement with natural chromium isotopic composition that appeared in literature. A marked enrichment of $^{54}Cr$, $^{53}Cr$ and $^{50}Cr$ due to cosmic-ray products could be observed in chromium isolated by solvent extraction from meteorite solutions. An isotopic dilution analysis using enriched $^{50}Cr$ or $^{52}Cr$ was made to obtain absolute content of these cosmogenic nuclides. The overall contents of $^{53}Cr$ and $^{54}Cr$ were found to be in the range of 13 to 25 ppB in several meteorites. The experimental procedure is described in detail here. (NSA of Japan)

**1980** FINE STRUCTURE OF THE RADIO SOURCE CYGNUS A. Wade, C. M. (National Radio Astronomy Observatory, Charlottesville, Va.). Phys. Rev. Lett., 17: 1061-2(Nov. 14, 1966).

The fine structure of Cygnus A, as deduced from interferometric observations at the National Radio Astronomy Observatory, is briefly discussed. Data were obtained on each of the six available base-line lengths, which range from 10,800 to 24,280 λ at the operating wavelength of 11.1 cm. The data were distributed in a very asymmetrical way on the Fourier transform plane. (W.D.M.)

**1981** OCCURRENCE OF SINGULARITIES IN COSMOLOGY. Hawkins, S. W. (Cambridge Univ., Eng.). Proc. Roy. Soc. (London), Ser. A, 294: 511-21(Oct. 18, 1966).

It is shown that singularities of space–time are inevitable if the Einstein equations hold, if matter has normal properties, and if the universe satisfies certain reasonable global conditions. The singularities would be in the past and would, in principle, be observable. Observation to determine whether such singularities actually occurred would provide a powerful test of the Einstein equations in strong fields. The singularity would not necessarily constitute a beginning of the universe. (auth)

**1982** SPECTRUM AND DISTANCE OF SOURCE SCO XR-1. Friedman, H.; Byram, E. T.; Chubb, T. A. (Naval Research Lab., Washington, D. C.). Science, 153: 1527-8(Sept. 23, 1966).

In a broad sky survey for x-ray sources in the 44- to 60-Å range only Sco XR-1 was detected. The spectral evidence indicates that Sco XR-1 may lie within a few hundred light years of the sun. Its spectrum appears to be complex—possibly a mixture of thermal sources at different temperatures or of thermal and nonthermal components, as has been predicted for an active neutron star with an associated corona or magnetosphere. (auth)

**1983** MOTIONS OF MATTER AT DIFFERENT SOLAR ATMOSPHERIC LEVELS IN ACTIVE REGIONS DURING FLARES. Gopasyuk, S. I. Izv. Krymsk. Astrofiz. Observ., 32: 14-25 (1964). (In Russian).

Motions of matter at the photospheric and chromospheric levels were studied, using recordings of radial velocities obtained in the FeI λ 4886.3 and $H_\beta$ lines with the magnetograph of the solar tower telescope. Assuming that the gas density in the flows is equal, it was found that at the photospheric level: (1) In the absence of flares the ratio of the flow of the descending gas to that of the ascending gas in an active region is close to 2.5. (2) During large flares: (a) there is an increase in the ascending and descending gas velocities in spot regions (umbra plus penumbra) while outside spots the velocities do not change practically; (b) there is a marked increase in the flow of the ascending gas in spot regions and an inconsiderable increase outside spot regions. (3) During flares the flows of the ascending and descending gas do not wholly equalize in all of the active region and the flow ratio decreases to 1.4 and then after a flare again attains 2.0 to 2.5. (4) After the maximum of flare $3^+$ of April 1, 1960, at the chromospheric level the flow ratio was 11.0, exceeding by about a factor of 7 the value in the absence of flares. (5) The results of observations at chromospheric and photospheric levels are in agreement if it is assumed that during flares matter ascends from the photosphere to the chromosphere and then descends. (auth)

**1984** A DETERMINATION OF THE SOLAR ABUNDANCES OF SEVERAL ELEMENTS USING THE SUNSPOT SPECTRA. II. THE PROOF OF THE METHOD. A DETERMINATION OF LITHIUM ABUNDANCE IN A SUNSPOT. Dubov, E. E. Izv. Krymsk. Astrofiz. Observ., 32: 26-31(1964). (In Russian).

The assumptions made in developing of the method are shown to be appropriate and to not affect the accuracy of abundance determination. It is shown also that the evaluation of scattered light in sunspot spectra is correct. The lithium abundance within the sunspot is 7.5 times more than its photospheric abundance, and equals to $\lg N_{Li} = 1.81$ (if $\lg N_H = 12.00$). (auth)

**1985** MOTIONS CONNECTED WITH MOUSTACHES. Koval, A. N. Izv. Krymsk. Astrofiz. Observ., 32: 32-7(1964). (In Russian).

On the basis of a large number of spectra of moustaches obtained with the solar tower telescope during 1958 to 1961 it was found that moustaches are accompanied by shifts of absorption lines to the shortwave side and jets to the longwave side. The lines were often zigzag. The velocity and evidently the character of the motions did not depend on the position of the moustaches on the solar disk. The motions to the shortwave and longwave side showed a velocity increase with height in the solar atmosphere. (auth)

**1986** EMISSION OF METALS IN FLARES. Banin, V. G. Izv. Krymsk. Astrofiz. Observ., 32: 38-45(1964). (In Russian).

It is shown that the emission of metals in coronal flare regions is similar to that observed in sunspot prominences and differs from that in chromospheric flare regions. The brightening of metals at the initial phase of development was followed in the flare of September 26, 1963. (auth)

**1987** ABUNDANCES OF THE IRON GROUP ELEMENTS IN THE ATMOSPHERE OF SIRIUS. Warner, B. (Radcliffe Observatory, Pretoria). Mon. Notic. Roy. Astron. Soc., 133: 389-400(1966).

Abundances in the atmosphere of Sirius are given for the iron group elements. A semi-empirical model atmosphere analysis is employed, using equivalent widths and oscillator strengths for the once ionized iron group. It is shown that the f-value data are free of serious systematic errors as functions of wavelength or excitation potential. The abundances show that Sirius has some of the characteristics of a metallic line star, but the overabundances are not as extreme as have been found by some previous investigators. A list of astrophysical absolute f values is given for Fe(II). (auth)

**1988** PHYSICAL CONDITIONS AND VELOCITY DISTRIBUTION IN THE ENVELOPE OF RR TELESCOPII. Friedjung, M. (Radcliffe Observatory, Pretoria). Mon. Notic. Roy. Astron. Soc., 133: 401-10(1966).

Spectra of the slow nova RR Telescopii, taken at the Radcliffe Observatory during its nebular stage, were spectrophotometrically examined. Half-intensity widths were measured for lines with little blending. If these widths are interpreted as expansion velocities, the velocities are greater for lines produced by ions of greater ionization potential, but decreased with time for each stage of ionization. Such effects can be understood if deceleration is assumed to occur in an envelope ionized by radiation from a central star of changing surface temperature; in this model there will be associated changes in the size of ionization regions but the highest ionization will occur close to the star. Mean electron temperatures were determined for the envelope, but they are probably higher near the central star. The ratio of He(II) to H recombinations was determined for one date (1965) and can be interpreted as either due to a temperature of order 200,000° (by Ambartsumian's method) or to an abundance ratio of order He(II)/H = 0.4. (auth)

**1989** ON THE INTERPRETATION OF RADIO SOURCE COUNTS. Longair, M. S. (Mullard Radio Astronomy Observatory, Cambridge, Eng.). Mon. Notic. Roy. Astron. Soc., 133: 421-36(1966).

A new numerical technique for investigating the cosmological implications of radio source counts is described. Using all the available observational data, it is shown that the counts of radio sources are consistent with evolutionary cosmologies in which the properties of a class of powerful radio sources, tentatively identified with quasi-stellar sources, evolve with epoch. From the satisfactory models, it is found that: (1) the local $\rho(P)$ luminosity function may be derived; (2) the mode of evolution of these powerful sources with epoch may be determined; and (3) the universe is isotropic to a redshift of at least 4. The models may be readily compared with future observations as they become available. (auth)

**1990** CONNECTION BETWEEN INCREASED SOLAR RADIO EMISSION IN THE METER RANGE AND ABSORPTION IN THE POLAR CAP. Levitskii, L. S. Izv. Krymsk. Astrofiz. Observ., 32: 84-7(1964). (In Russian).

Increased solar radio emission in the meter range of the short-duration noise storm type (from three hours to three days) was studied. It is shown that this emission in 40% of the cases is connected with centimeter radio bursts and is directed. It often originates after flares which are accompanied by absorption in the polar cap. (auth)

**1991** EVOLUTIONARY INTERPRETATION OF THE SPECTRUM–LUMINOSITY DIAGRAM FOR HOT STARS. I. PARAMETERS OF THE INITIAL MAIN SEQUENCE. Kopylov, I. M. Izv. Krymsk. Astrofiz. Observ., 32: 88-99(1964). (In Russian).

The main parameters of the initial MS (the zero age sequence) were determined by two independent methods. The first consists in the reference of homogeneous models of stellar interiors with different masses to the spectral sequence. The second, which is usually used, consists in the determination of the parameters of the initial MS from the results of spectroscopic and photometric observations of stars and star groups (galactic clusters and associations). The values of the parameters of the initial MS in the B0–K7 spectral interval found by both methods are in good agreement. In the O5–B0 and M0–M7 interval the discordances are quite large. A table is given in which the main parameters of population I stars are summarized. The deficiencies of the methods and some reasons for the detected discrepancies are noted. (auth)

**1992** ON THE TWO-DIMENSIONAL LUMINOSITY–COLOR FUNCTION FOR SUPERGIANTS. Chentsov, E. L. Izv. Krymsk. Astrofiz. Observ., 32: 100-7(1964). (In Russian).

A more precise determination was made of the luminosity and color distribution of stars of the Galaxy, LMC, and M31 with $M_v < -3^m$. It was found that besides blue and red supergiants there are stars with intermediate color which form an isolated group in the $M_v$, $(B-V)_0$ diagram. (auth)

**1993** SOUND VELOCITIES IN HOT SUPERGIANT ATMOSPHERES. Hollandskii, O. P. Izv. Krymsk. Astrofiz. Observ., 32: 127-32(1964). (In Russian).

Sound velocities in the atmospheres of O5–A2 supergiants Ia and Ib were computed taking radiation pressure into account. For the hotter stars these velocities considerably exceed the usual sound velocity, determined only by gas pressure. The microturbulent velocities are subsonic relative to the velocities obtained, while in several cases they exceed the usual sound velocity. (auth)

**1994** PHOTOMETRIC AND COLORIMETRIC CHARACTERISTICS OF ERUPTIVE STARS. Gershberg, R. E. Izv. Krymsk. Astrofiz. Observ., 32: 133-54(1964). (In Russian).

Nonstable emission stars of different types can be regarded as compound systems, each of which consists of a quasi-normal star and a hot optically thin gaseous body. This nebular model explains many photometric and colorimetric peculiarities of these nonstable objects. The light curves of nova in the nebular stage are interpreted. The light curves of flares of uv Ceti-type stars are analyzed quantitatively. The densities, dimensions, masses, temperatures, expansion velocities, and expected thermal radio emission of radiant gaseous bodies are evaluated. On the basis of these data some conclusions are made on the mechanism responsible for flares. On the basis of the nebular model the two-color and color–magnitude diagrams of flare stars are interpreted and some colorimetric features of T Tau- and SS Cyg-type stars discussed. In conclusion several considerations on the expedient observations of eruptive stars are given. (auth)

**1995** IONOSPHERIC EFFECTS OF PROTON AND NON-PROTON FLARES FROM OBSERVATIONS AT THE IONOSPHERIC STATION OF THE CRIMEAN ASTROPHYSICAL OBSERVATORY. Vinogradov, Yu. I. Izv. Krymsk. Astrofiz. Observ., 32: 67-75 (1964). (In Russian).

The influence of proton and non-proton flares on all the ionospheric regions was studied in 22 cases of SID using the experimental data obtained at the ionospheric station of the Crimean Astrophysical Observatory during 1957 to 1958. It is shown that principal differences in the influence of the studied flares on the F2, E, and D ionospheric regions are not observed. (auth)

**1996** RELATION BETWEEN X RADIATION OF SOLAR FLARES AND THEIR EFFECTS IN COSMIC RAYS. Vladimirskii, B. M.; Pankratov, A. K. Izv. Krymsk. Astrofiz. Observ., 32: 46-55(1964). (In Russian).

From a comparison of ionospheric effects of flares with small increases (<1%) in cosmic-ray intensity at sea level (nucleon component) it follows that: (1) Stronger effects in the ionospheric D layer correspond in the mean to an appreciably higher increase of cosmic rays at sea level. (2) The appearance of absorption in the D layer, i.e., an x-ray flux with $\lambda \leq 8$ Å, is a necessary but not sufficient indication of the appearance of a small effect in cosmic rays at sea level. (auth)

**1997** GALACTIC AND SOLAR NUCLEOSYNTHESIS. Kuroda, P. K.; Rowe, M. W.; Clark, R. S.; Ganapathy, R. (Univ. of Arkansas, Fayetteville). Nature, 212: 241-3(Oct. 15, 1966). (ORO-3235-1).

The hypothesis that spontaneous fission of extinct $^{244}Pu$ is responsible for the xenon isotope anomaly in the mass region 131 to 136 was put forward by Kuroda in 1960. A dozen meteorites were investigated and appeared to fit an isochron corresponding to the $^{244}Pu-^{136}Xe$ formation interval (300 m yr), whereas the values of the $^{129}I-^{129}Xe$ formation interval tended to scatter randomly within the range 100 to 300 m yr. These results can be interpreted on the basis of the postulate that $^{244}Pu$ is synthesized solely in the supernova explosion, while $^{129}I$ can be synthesized in the solar, as well as in the galactic processes. The iodine and uranium contents of the meteorites were determined using the neutron-activation technique, irradiating the samples in the CP-5 at ANL. (W.D.M.)

**1998** SPECTRUM OF THE GALACTIC RADIO EMISSION. Purton, C. R. (Cavendish Lab., Cambridge, Eng.). Mon. Notic. Roy. Astron. Soc., 133: 463-74(1966).

The output spectra of three diode noise sources were measured over the frequency range 13 to 178 Mc and were found to conform to theory. This method yielded a determination of the output at any particular frequency accurate to about 2%. These diode noise sources were used as the basis for measurements of sky brightness, using geometrically scaled antennas, over the same frequency range. The results of observations of the sky brightness at 81.5 Mc, measured with a similar scaled aerial, are presented. The spectrum of the general radio emission from the galactic halo and from the galactic disk in the direction of the anticenter was determined over the frequency range 13 to 404 Mc. The spectral index $\alpha$ varies with frequency in both regions. Differences between the two spectra are not significant. This spectrum is in good agreement with recent measurements of the energy spectrum of cosmic-ray electrons. (auth)

**1999** STRUCTURE OF THE RADIO SOURCES 3C 46, 66, 129, AND 465. Macdonald, G. H.; Neville, A. C.; Ryle, Martin (Cavendish Lab., Cambridge, Eng.). Nature, 211: 1241-4(Sept. 17, 1966).

A series of observations of 3C 46, 66, 129, and 465 were carried out with the Cambridge one-mile radio telescope to determine the angular structure of these relatively intense radio sources. The structure of the four complex sources which are believed to be extragalactic is described. The observations were made at 408 and 1,407 Mc using a method in which 12-hour observations are made with the movable aerial at each of a number of positions along the full length of the rail track. (W.D.M.)

**2000** COSMOLOGICAL SIGNIFICANCE OF THE RELATION BETWEEN RED-SHIFT AND FLUX DENSITY FOR QUASARS. Sciama, D. W.; Rees, M. J. (Cambridge Univ., Eng.). Nature, 211: 1283(Sept. 17, 1966).

It is pointed out that recent measurements of the red shifts of quasars provide the most decisive evidence obtained so far against the steady-state model of the universe. The red shift is plotted against the flux density for the 35 quasars for which the red shift is known. It is concluded that if the red shifts of quasars are cosmological in origin, then the red shift–flux density relation rules out the steady-state model of the universe. (W.D.M.)

**2001** POSSIBLE GALACTIC ORIGIN FOR QUASI-STELLAR SOURCES. Odgers, G. J. (Dominion Astrophysical Observatory, B. C.); Stewart, R. W. Nature, 211: 1284(Sept. 17, 1966). (BNL-10336).

The cosmological interpretation of the observed red shifts of quasars gives rise to severe difficulties concerning the energy output and variation of light. The possibility is suggested that the observed red shifts result from an inflow of matter at relativistic velocities in the gravitational field of a highly condensed white dwarf with a very large escape velocity. The possibility is discussed and it is suggested that the white dwarf would provide a double radio source, point source with large red shift, optical synchrotron radiation, and soft x rays. (W.D.M.)

**2002** STRUCTURE AND EVOLUTION OF BARRED SPIRAL GALAXIES. II. Freeman, K. C. (Trinity Coll., Cambridge, Eng.). Mon. Notic. Roy. Astron. Soc., 134: 1-14(1966).

Exact, self-gravitating, homogeneous, ellipsoidal, rotating, collisionless stellar systems were constructed, such that the centrifugal and gravitational forces balance along the major axis. Their approximate evolution, as they lose mass, energy, and angular momentum, was computed by using the adiabatic invariants associated with each stellar orbit. The results suggest that the bar of an SB galaxy will become more dense and stubby and rotate more rapidly as it evolves. They indicate that, if there is an evolutionary pattern inherent in the Hubble classification, the direction of evolution would be SBc → SBa. (auth)

**2003** STRUCTURE AND EVOLUTION OF BARRED SPIRAL GALAXIES. III. Freeman, K. C. (Trinity Coll., Cambridge, Eng.). Mon. Notic. Roy. Astron. Soc., 134: 15-23(1966).

The structure of a family of inhomogeneous, uniformly rotating, self-gravitating, elliptical disks of stars is described. The systems were used to represent the bar of an SB galaxy, and their evolution, as they lose mass, energy, and angular momentum, was computed. The implications for the evolution of barred spiral galaxies agree with those described previously. (auth)

**2004** MAGNETIC FIELDS AND GAS STREAMING IN SPIRAL GALAXIES. Freeman, K. C.; Mestel, L. Mon. Notic. Roy. Astron. Soc., 134: 37-51(1966).

Models of steady large-scale gas streaming in galaxies were studied, with magnetic forces playing an essential role. For ordinary spirals, with gravitational fields that are approximately axially symmetric, the conclusions of others that it is very difficult to build a plausible model, in which the magnetically driven streaming maintains a steady pattern in spite of the large rotational shear are confirmed. Magnetic forces are therefore likely to be only locally important in the dynamics of spiral arms. For barred spirals it is possible to construct a model that does not demand excessively strong fields, but it is doubtful whether the magnetic torque is as important as the gravitational and Coriolis torques, except in cases with streaming velocities much below those observed in some barred spirals. (auth)

**2005** X-RAY ASTRONOMY. Chubb, Talbot A. Endeavour, 25: 136-40(Sept. 1966).

The present status of x-ray astronomy research is briefly reviewed. Several aspects of solar and stellar x rays are discussed. Future areas of research are pointed out. (M.O.W.)

**2006** TAYLOR SERIES FOR THE CONVECTIVE CORE IN A STELLAR MODEL. Meggitt, S. M. A. (Australian National Univ., Canberra). Austral. J. Phys., 19: 607-14(Oct. 1966).

The first seven terms of the Taylor expansion about the center for the solutions of a convective core with radiation pressure have been calculated. This truncated series can be used to calculate the values of quantities in the core for cores up to 40% of the radius and for radiation pressure up to $1 - \beta_c = 0.2$. (auth)

**2007** CHAINS OF TYPE I SOLAR RADIO BURSTS. Hanasz, J. (CSIRO, Chippendale, New South Wales). Austral. J. Phys., 19: 635-47(Oct. 1966).

Statistical investigations of "chains" of type-I bursts recorded with the Dapto radio spectrograph are reported. Various characteristics of chains have been investigated, including their distribution with mid frequency, rate of frequency drift, position on the solar disk, lifetime, and the frequency separation of pairs. No distinction has been found between the physical properties of chains and of single bursts. The mean speed of source propagation deduced from rates of frequency drift (assuming the plasma hypothesis and "2 × Newkirk" model of the corona) is found to be 200 km/sec in the outward direction, although about one-quarter move in towards the photosphere. The observations are briefly discussed in relation to the suggestion of Wild and Tlamicha (1965) that the chains might be produced in magnetohydrodynamic shock waves propagating through the corona. (auth)

**2008** ACCURATE POSITIONS OF 644 RADIO SOURCES. Shimmins, A. J.; Clarke, Margaret E.; Ekers, R. D. (CSIRO, Chippendale, New South Wales). Austral. J. Phys., 19: 649-85 (Oct. 1966).

The right ascensions and declinations of 644 extragalactic radio sources have been determined. For most sources the estimated error is less than 15″ arc in each coordinate. The sources were selected from the Parkes Catalogue of Radio Sources for the declination range +20° to −90°. (auth)

**2009** CONSERVATION LAWS. Cattaneo, C. Ann. Inst. Henri Poincare, Sect. A, 4: 1-20(Jan. 1-Feb. 15, 1966).

A model is given of a rotating universe which is steadly expanding. Initially the three pressures are equal. If one assumes an initial rate of expansion of the order of $10^{-28}$, the model will have a lifetime of the order of $10^{10}$ years, after which the density of the model will be negative and it loses physical significance. The model is filled with fluid whose pressure is nonisotropic. The geometry of the model is very much similar to that of Godel's stationary model. (M.O.W.)

**2010** ASTROPHYSICAL EVIDENCE FOR THE DIRECT ELECTRON–NEUTRINO WEAK INTERACTION. Chin, Chao-wen (Goddard Inst. for Space Studies, New York. Columbia Univ., New York); Chiu, Hong-yee; Stothers, Richard. Ann. Phys. (N. Y.), 39: 280-99(Sept. 1966).

Observational evidence exists that the central stars of planetary nebulae are evolving into white dwarfs. However, a "gap" in the stellar population appears between the faintest central stars ($100L_\odot$) and the brightest white dwarfs ($1L_\odot$). Theoretical models of superluminous white dwarfs (Gap stars) are constructed with and without the inclusion of neutrino emission processes. It is known from previous work that neutrino emission speeds up the evolution of a star. The particular process of importance here is the plasma neutrino process of Adams, Ruderman, and Woo, which depends critically on the existence of the $(e\nu_e)(e\nu_e)$ interaction. It was found that the evolution of stars in the mass range 0.7 $M_\odot$ to 1.1 $M_\odot$ (Chandrasekhar mass limit for white dwarfs = 1.4 $M_\odot$) is accelerated by a factor of 10 to 100, depending on the assumed chemical composition, if plasma neutrino emission is included; below 0.4 $M_\odot$, neutrino emission is unimportant. The more massive Gap stars may be identified observationally on the basis of their very blue color. An upper limit to their evolution time is then obtained from a variety of observational arguments; this upper limit is $5 \times 10^5$ years, to be compared with the theoretical lifetimes of $2 \times 10^5$ years with neutrino emission and $2 \times 10^6$ years without it. From these results the following conclusions can be drawn: the presently known rate of plasma neutrino energy loss roughly reproduces the astronomical data; the weak interaction coupling constant for the $(e\nu_e)$ $(e\nu_e)$ interaction has a lower limit close to the currently accepted value. Further evidence from the known observational lifetime of central stars and from some crude stellar models indicates that neutrino emission (photoneutrino process) may also be accelerating evolution in the central stars. (auth)

**2011** QUASARS. Smith, Harlan J. (Univ. of Texas, Austin). Appl. Opt., 5: 1701-19(Nov. 1966).

A short historical outline of the discovery and a description of observed properties of quasars introduces questions as to their nature. Some of the principal arguments concerning their reality, distance, intrinsic properties, and age lead to the conclusion that, while there is room for other points of view, a strong case can be made for the interpretation, on which quasars are the most distant observable objects in the known universe. To produce such luminosities over times of thousands to millions of years requires the presence of millions of solar masses. For each quasar this enormous mass may be concentrated into a single object, in which case novel physics comes into play. Whatever the final interpretation, quasars seem certain to illuminate such questions as the origin and evolution of galaxies, perhaps also the structure and origin of the universe. (auth)

**2012** GRAVITATIONAL COLLAPSE AND WEAK INTERACTIONS. Arnett, W. David (National Aeronautics and Space Administration, New York). Can. J. Phys., 44: 2553-94(Nov. 1966).

The behavior of a massive star during its final catastrophic

stages of evolution was investigated theoretically, with particular emphasis upon the effect of electron-type neutrino interactions. The methods of numerical hydrodynamics, with coupled energy transfer in the diffusion approximation, were used. In this respect, this investigation differs from the work of Colgate and White (1964) in which a "neutrino-deposition" approximation procedure was used. Gravitational collapse initiated by electron capture and by thermal disintegration of nuclei in the stellar center is examined, and the subsequent behavior does not depend sensitively upon which process causes the collapse. As the density and temperature of the collapsing stellar core increase, the material becomes opaque to electron-type neutrinos and energy is transferred by these neutrinos to regions of the star less tightly bound by gravity. Ejection of the outer layers of the star can result. This phenomenon has been identified with supernovae. Uncertainty concerning the equation of state of a hot, dense nucleon gas causes uncertainty in the temperature of the collapsing matter. This affects the rate of energy transfer by electron-type neutrinos and the rate of energy lost to the star by muon-type neutrinos. The effects of general relativity do not appear to become important in the core until after the ejection of the outer layers. (auth)

**2013** PHYSICAL PROCESSES AND SUPERNOVA DYNAMICS. Arnett, William David. New Haven, Yale Univ., 1966. 149p.

Thesis.

A detailed history of the evolution of supernova models has been calculated. Neutrino energy transfer in the dense central regions is considered in the diffusion approximation, with opacities corrected for electron degeneracy. The calculational technique involved numerical solution of coupled difference equations for diffusive energy transfer and hydrodynamic flow; these techniques are discussed. The condensed-core presupernova model of Chiu and the less-condensed model of Fowler and Hoyle have been evolved through collapse and subsequent mass ejection, and comparison indicates that interior dynamics does not depend sensitively upon the initial structure of the models. These calculations also suggest that a careful treatment of muon-type neutrino processes is needed. Diffusive energy transfer by electron-type neutrinos in an imploding supernova tends to increase the amount of energy available to eject matter. This is because energy loss during the early stages of the implosion causes the core to fall in to higher density, and thus allows more gravitational energy to be released than would be the case if neutrino effects were neglected. (Dissertation Abstracts)

**2014** BISTATIC-RADAR MEASUREMENTS OF INTERPLANETARY COLLISIONLESS SHOCK WAVES. Gee, Sherman. Stanford, Calif., Stanford Univ., 1966. 112p.

Thesis.

The problem was to investigate the possibility of detecting and measuring shock waves propagating outward from the sun by using bistatic-radar transmissions from Earth to an interplanetary spacecraft. The application and extension of existing bistatic-radar techniques to this specific problem were developed. By determining the propagation characteristics of the electromagnetic wave in the presence of a magnetic field and including the effect of the streaming medium, methods were derived by which the average electron density and stream velocity along the propagation path might be measured. Typical responses of the electromagnetic wave to the presence of the shock wave were established. The magnitudes of the responses provided sufficient information to establish a number of magnetoacoustic shock parameters characterizing the shock intensity. The proposed radar measurements could, in addition, possibly detect shock-density oscillations as well as provide information needed to help resolve certain fundamental questions concerning the structure of collisionless shock waves. The conclusion is that the transmission of an electromagnetic wave to a spacecraft could indeed be employed to detect and measure interplanetary shock waves. The observational results would then serve as valuable inputs toward a better understanding of the collisionless shock. (Dissertation Abstracts)

## Atomic and Molecular Physics

*Refer also to abstracts 2312, 2323, and 2692.*

**2015** (CEA-R-2983) DISSOCIATION VIBRATIONNELLE ET DISSOCIATION EN CASCADE D'IONS $H_2^+$ PAR COLLISIONS AVEC LES MOLECULES D'UN GAZ. (Vibrational and Cascade Dissociation of $H_2^+$ Ions by Collision with Gas Molecules). Verveer, Philippe (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). July 1966. 58p. (In French). (EUR-2767.f). Dep. mn.

Thesis. Submitted to Paris Univ. (France). Faculte des Sciences

Protons produced by collisional dissociation of $H_2^+$ ions have an energy spectrum with a narrow central peak. For a part the protons in this peak are produced by vibrational dissociation and for another part by a cascade of two collisions. For $H_2^+$ ions of 50 to 150 keV the cross section for vibrational dissociation is about 4,1 $10^{-19}$ $cm^2$/mol. in hydrogen and 1,1 $10^{-18}$ $cm^2$/mol. in argon. (tr-auth)

**2016** (INP-485/PL) HIGH RESOLUTION TRANSVERSE SUM RULES FOR ELECTRONS SCATTERED INELASTICALLY FROM LIGHT NUCLEI. Czyz, Wieslaw; Lesniak, Leonard; Malecki, Andrzej (Institute of Nuclear Physics, Krakow (Poland)). June 1966. 44p. Dep.

A series of sum rules for inelastic electron scattering at $\theta = 180°$ is proposed. Each of them contains contributions from transitions of a given multipolarity. This approach is applied to study the form factors of the giant dipole resonance and the results are compared with the existing experimental data and the results of calculations based on the microscopic theory of the dipole vibrations in nuclei. (auth)

**2017** (ORNL-tr-1383) MEASUREMENT OF THE CURRENT OF AN ELECTRON BEAM. Michalak, Stanislaw. Translated for Oak Ridge National Lab., Tenn., from Zesz. Nauk Uniw. Lodz., Ser. II, 17: 69-71(1964). 5p. Dep. mn. JCL $1.10 fs, $0.80 mf.

A schematic diagram of the measuring apparatus is presented. Current flowing between a metal target and the ground is measured with a microammeter. Various secondary effects were considered. (M.O.W.)

**2018** FOCUSING CHARACTERISTICS OF ELECTRIC FIELDS. Higatsberger, Michael J. (Oesterreichische Studiengesellschaft fuer Atomenergie GmbH, Seibersdorf, Austria). Acta Phys. Austr., 23: 171-80(1966). (In German).

The focusing properties of electric fields in pure ion and electron lenses, ion propulsion systems, and ion sources are discussed. Recent applications of electric fields in optical systems are reported as illustrations. (J.S.R.)

**2019** RENORMALIZATION PHENOMENA IN THE QUANTUM THEORY OF RADIATION OF HIGH INTENSITY. Ehlotzky, F. (Univ., Innsbruck). Acta Phys. Austr., 23: 95-126(1966).

The interaction of a free electron with an intense beam of coherent light of low frequency is investigated within the framework of standard quantum electrodynamics, after the work of Stehle and DeBaryshe, and of Fried and Eberly. It is shown that the renormalization of the electron propagator and of the electron wave function, which arises from the unobservable effect of forward scattering, can be exactly evaluated in the semiclassical limit to all orders of the S-matrix expansion. The results can be expressed in terms of convergent, infinite continued fractions, which, being meromorphic functions of the effective coupling constant, may be represented by suitable combinations of Bessel functions. Comparison is made with previous calculations of Fried and Eberly. Some more general problems are also discussed. (auth)

**2020** DETERMINATION OF THE OPTIMUM CONVERTER FOIL BY MEASUREMENT OF GAMMA RADIATION WITH EXTERNAL CONVERSION. Riedlmayer, L. (Technische Hochschule, Vienna). Acta Phys. Austr., 23: 199-203(1966). (In German).

A method is described and discussed which makes it possible, on the basis of theoretical considerations, to determine that converter foil (atomic number Z) for which the best photoelectric yield is to be expected with consideration of a given maximum mean energy loss; also to determine that converter foil for which, in use of sufficiently thick converters, the highest line intensity is to be expected. (tr-auth)

**2021** MEASUREMENT OF ELECTRON-BREMSSTRAHLUNG REACTION CROSS SECTION FOR 2.04-Mev ELECTRONS. Aigingen, Hannes; Zinke, Hugo (Oesterreichische Hochschule, Vienna). Acta Phys. Austr., 23: 76-87(1966). (In German).

The differential electron-bremsstrahlung effective cross section $d^2/dkd\Omega$ of 2.04-MeV electrons was measured at the angles 10, 20, and 30°. Al(Z = 13) and Au(Z = 79) were used as target materials. The measured values are compared with theory and the high-energy range is considered in detail. The production of the operational matrix of the 5 × 5″ NaI (Tl) spectrometer and the installation used in the measurement are described. (tr-auth)

**2022** ON THE TRANSITION PROBABILITY IN IONIZATION OF ATOMS BY COLLISION. II. IONIZATION OF ATOMS BY COLLISION WITH EXCITED HELIUM. Mori, Masatake (Tokyo Univ.). J. Phys. Soc. Jap., 21: 977-86(May 1966).

Ionization of an atom by collision with another excited atom, $A^* + B \rightarrow A + B^+ + e$, is discussed theoretically, where the transition $A^* \rightarrow A$ is optically allowed. Approximate formulas for the cross-section are derived by two independent methods from the funda-

mental equations of time-dependent perturbation. The cross-section of the above process varies as $v^{-\frac{1}{2}}$, where v is the relative velocity of the atoms. (NSA of Japan)

**2023** VARIATIONS IN THE TOWNSEND FIRST IONIZATION COEFFICIENT FOR GASES. Cookson, A. H.; Lewis, T. J. (Queen Mary Coll., London). Brit. J. Appl. Phys., 17: 1473-81 (Nov. 1966).

The distributions of sizes of electron avalanches in methane gas subjected to uniform electric fields no longer satisfy the simple exponential Furry distribution when the ratio $E/p_0$ exceeds 50 v $cm^{-1}$ $torr^{-1}$. The reasons for this deviation were explained previously by Legler, who suggested that the probability of ionization was a function of the distance traveled by electrons from their previous ionizing collision. An alternative explanation is offered which suggests that the effect is due to the first Townsend ionization coefficient a decreasing monotonically with the avalanche size, so giving Polya distribution. Such a decrease in a is consistent with the process by which the energy distribution of electrons emitted from the cathode gradually reaches a stationary state in the gas. An analysis based on the Polya distribution also gives results in good agreement with the hitherto apparently unrelated investigations of other workers. (auth)

**2024** A PRECISE MEASUREMENT OF THE ANGULAR CORRELATION OF ANNIHILATION RADIATION IN COPPER SINGLE CRYSTALS. Fujiwara, Kunio; Sueoka, Osamu (Tokyo Univ.). J. Phys. Soc. Jap., 21: 1949-57(Oct. 1966).

A precise measurement of the angular correlation of two gamma rays emitted from copper single crystals by the annihilation of positrons has been carried out. The crystals were irradiated by neutrons to produce 1 ~ 2 Ci of $^{64}Cu$ so that the positrons were confined in the crystals. This containment of the strong positron sources in the crystals allowed us to use two pairs of slits perpendicular to each other rather than the ordinary one pair of slits. With this geometry inaccuracies in determining the shape of the Fermi surface due to poor resolutions were considerably eliminated. The necks of the Fermi surface of copper were found on the curves of the angular correlation. The observed value of the radius of these necks, $2.7 \times 10^{-20}$ gr·cm/sec, agrees with those obtained by the magnetoacoustic effect, etc. The maximum momentum of electrons in the ⟨111⟩-directions was found to be $1.60 \times 10^{-19}$ gr·cm/sec, which agrees well within the experimental error with the distance of the {111}-Brillouin zone boundaries from the origin of the momentum space, $1.587 \times 10^{-19}$ gr·cm/sec. The latter fact gives a new evidence of the current conclusion that the annihilating electron pair moves freely from the other electrons in metals. The present method of containment of the strong positron sources in specimens themselves will be useful for the investigation of the Fermi surfaces of various copper alloys which have never been studied by other experimental methods. (auth)

**2025** MEASUREMENT OF THE ELECTRON ENERGY SPECTRUM RESULTING FROM A DOUBLE AUGER PROCESS IN ARGON. Carlson, Thomas A.; Krause, Manfred O. (Oak Ridge National Lab., Tenn.). Phys. Rev. Lett., 17: 1079-83 (Nov. 21, 1966).

Earlier investigations on the double Auger process were based on measurements of the relative abundances of the differently charged ions that result from the readjustment to an inner-shell vacancy. A measurement of the energy distribution of the electrons ejected in the double Auger process should be of great value in evaluating the phenomena. The results of such a study on the $L_{II,III}MMM$ transition in argon are presented. The experiment consisted of irradiating argon with x rays in an electron spectrometer, and measuring the energy spectrum of electrons emitted in the readjustment to holes in the $L_{II,III}$ shell. (W.D.M.)

**2026** CHARGE EXCHANGE IN SLOW COLLISIONS. Smirnov, B. M. Teplofiz. Vysok. Temp., 4: 429-49(May-June 1966). (In Russian).

Charge exchange cross sections for collisions of slow atomic particles were calculated considering that the cross sections are considerably larger than the corresponding atomic magnitude. The computation method was based on the two-level approximation utilizing asymptotic properties of a quasimolecule composed of colliding atomic particles. A systematic correlation was made of the calculations and experimental data on the resonance and nonresonance charge exchange with a small resonance defect are given. (tr-auth)

**2027** ELECTROMAGNET OF A SPECTROMETER FOR THE OBSERVATION OF THE NUCLEAR MAGNETIC AND THE ELECTRON PARAMAGNETIC RESONANCE. Sazonov, A. M. Izv. Leningr. Elektrotekh. Inst., 62: 141-50(1964). (In Russian).

Nuclear magnetic and electron paramagnetic resonance studies on solids require a radiospectrometer provided with an electromagnet possessing a very uniform and constant magnetic field. Such a magnet, designated as Type CP-78 was designed and built. Its field may be changed from 100 to 10,000 oersted; the field is constant within $2 \times 10^{-5}$ oersted/cm and even $10^{-6}$ oersted/cm, if a special circuit is used. Stabilization was achieved by means of two independent circuits. The desired gap may be selected by means of an attached collar; the largest one was 48 mm. Operational characteristics of the system are illustrated by presenting nuclear magnetic resonance oscillograms of protons in water and of the $^{19}F$ nucleus in $C_6H_5F_3$, and the electron paramagnetic resonance signal of diphenyl picryl hydrazine. The nmr signals were recorded at a frequency of 19.827 MHz; the distance between peaks amounted to about 0.16 oersted. The radiospectrometer recording the epr signal was operated at 9410 MHz with a hf modulation of the magnetic field, recording the second harmonic of the signal; the oscillogram thus represented the second derivative of the absorption signal. (TTT)

**2028** PROTON MOTIONS IN COMPLEX HYDROGENOUS LIQUIDS. I. A CROSS SECTION FOR QUASI-ELASTIC SCATTERING OF SLOW NEUTRONS. Larsson, Karl-Erik; Bergstedt, Leif (Royal Inst. of Tech., Stockholm). Phys. Rev., 151: 117-25(Nov. 4, 1966).

A neutron-scattering cross section for quasi-elastic scattering from a complex hydrogenous liquid is derived. The internal motions of the proton within the molecule and possibly the motions of the protons between molecules have to be taken into account in a full description of the dynamical picture, and consequently have to be included in the interpretation of scattered neutron spectra. The motion of the scattering protons is described as a superposition of the motion of the proton with respect of the center of gravity of the molecule on the motion of the center of gravity itself. A rapid jump motion of the proton during the time $\tau_1$ is considered; the origin of the jump might be an isomeric rotation or a change of proton position due to jumps in a hydrogen bond. In between the jumps, the proton is supposed to vibrate for a time $\tau_0$. The motion of the center of gravity of the molecule is supposed to be either a diffusive motion for a time $\tau_1'$, if the molecule is free to move, or a vibration for a time $\tau_0'$, if the molecule is bound, for instance via hydrogen bonds to neighbors. (auth)

**2029** PROTON MOTIONS IN COMPLEX HYDROGENOUS LIQUIDS. II. RESULTS GAINED FROM SOME NEUTRON-SCATTERING EXPERIMENTS. Larsson, K. E.; Queroz do Amaral, L.; Ivanchev, N.; Ripeanu, S.; Bergstedt, L.; Dahlborg, U. (Royal Inst. of Tech., Stockholm). Phys. Rev., 151: 126-32 (Nov. 4, 1966).

A comparison is made between the theoretical model of the preceding paper and some neutron-scattering results obtained on n-propyl alcohol and pentane. The quasi-elastically scattered neutron intensity is analyzed in terms of the relaxation times $\tau_0$, $\tau_1$ $\tau_0'$, and $\tau_1'$, the jump length l of the proton, and the self-diffusion coefficient D of the molecular center of gravity. The nature of the quasi-elastically scattered neutron intensity is generally interpreted as a result of mixed protonic jumps and molecular diffusion. It is shown that the diffusion coefficients derived from neutron-scattering data consist of a combination $D + l^2/2\tau_0$, where for very low viscosities D dominates and for higher viscosities the protonic diffusion constant $l^2/2\tau_0$ dominates. Protonic jump lengths of 1.5 Å are observed. Definite values of the relaxation times $\tau_{00}$, $\tau_0'$, and $\tau_0$ are derived from the width of the quasi-elastic line. With the present resolution of the experimental equipment, times $\tau_{00}$ in the range $10^{-12}$ to $2 \times 10^{-11}$ sec may be studied. It is shown how in the low-temperature, high-viscosity ranges, $\tau_0'$ is much larger than $\tau_0$, the internal mean lifetime for a proton in a fixed-position. $\tau_0$ values in a range from $10^{-11}$ to $2.5 \times 10^{-12}$ are derived, whereas derived values of $\tau_0'$ for n-propyl alcohol range from $2.5 \times 10^{-9}$ to $2.75 \times 10^{-12}$ sec in a temperature range from 153 to 333°K. It is also shown for the case of pentane that when larger momentum transfers are studied in quasi-elastic scattering, the intensity of the resulting gaslike scattering picture is governed by a Debye–Waller factor. This is due to the fact that even if the center of gravity is moving like a gas particle, the proton jumps within the molecule continue. These results indicate that the quasi-elastic scattering has two components: a diffusive component of width $2\hbar(D + l^2/2\tau_0)\kappa^2$ and a gas component the width of which depends upon the degree of hindrance for the free recoil of a molecule in a collision. Which component dominates depends upon the magnitude of the momentum transfer $\hbar\kappa$ in the scattering process. (auth)

**2030** SODIUM-ELECTRON SPIN-EXCHANGE COLLISIONS. Balling, L. C. (National Bureau of Standards, Boulder, Colo.). Phys. Rev., 151: 1-6(Nov. 4, 1966).

A spin-exchange optical pumping experiment to study collisions between sodium atoms and free electrons is reported. In this experiment, electrons in a weak-magnetic field were polarized by spin-exchange collisions with optically pumped sodium atoms.

The sodium–electron collisions were the principal source of the electron resonance linewidth, and they also produced a shift in the electron resonance frequency. The magnitudes of the linewidth and the frequency shift depend upon the scattering amplitude for sodium–electron collisions, the sodium polarization, and the sodium atom density. The ratio of the frequency shift to the linewidth was 0.03. The sodium polarization was approximately 30%. The electron resonance frequency was lower when the sodium polarization was positive. The measurements of the electron linewidth and the frequency shift agree with theoretical values of the linewidth and frequency shift obtained from the sodium–electron scattering phase shifts recently calculated by Garrett. (auth)

**2031** REARRANGEMENT COLLISIONS. II. ELECTRON EXCITATION OF He($2^3$P). Joachain, Charles J. (Univ. of California, Berkeley); Mittleman, Marvin H. Phys. Rev., 151: 7-11(Nov. 4, 1966).

A systematic study is made of various first-order approximations to the T matrix for a rearrangement collision. Detailed calculations are performed for the process of excitation of the $2^3$P level of helium by electron impact. Comparison is drawn between the various theoretical cross sections obtained and the experimental data. The polarization of the emitted radiation is also studied. (auth)

**2032** CHARACTERISTIC X-RAY PRODUCTION IN ATOMIC L AND M SUBSHELLS. Khandelwal, G. S.; Merzbacher, E. (Univ. of North Carolina, Chapel Hill). Phys. Rev., 151: 12-13 (Nov. 4, 1966).

Explicit formulas are obtained for atomic form factors describing the energy loss and momentum transfer of a charged particle to electrons in the subshells of the L and M shells. The Bethe–Born approximation is used with hydrogenic wave functions. Application is made to the $L_{III}$ ionization cross section for protons incident on copper in the energy range from 0.5 to 1.7 MeV. (auth)

**2033** ELECTRON ENERGY DISTRIBUTIONS FROM IONIZING COLLISIONS OF HELIUM AND NEON IONS WITH HELIUM. Barker, R. B.; Berry, H. W. (Syracuse Univ., N. Y.). Phys. Rev., 151: 14-19(Nov. 4, 1966).

The electron-energy distributions arising from ionizing collisions of He and Ne ions with a He target were examined under conditions such that the instrumental resolution does not affect the distribution. Incident ions were in the range of 1 to 4 keV. The distributions consist of a sharp maximum near the zero of the electron energy with broader peaks occurring in the 20- to 40-eV region. Two broad peaks are detectable in the $He^+$–He spectrum and six are found in the $Ne^+$–He spectrum. The energies of the maxima of the prominent broad peaks were found to fit a linear dependence on the inverse ion velocity over all or part of the ion range investigated. This dependence, when extrapolated to infinite ion energy, yielded peak energies that correspond to previously identified autoionizing states. Where measurement is possible, these same peaks show a decrease in width at half maximum also linear with the inverse ion velocity. A model is presented, which attributes the observed behavior to a collision-induced excitation of autoionizing states followed by autoionization transitions in the field of the ion. (auth)

**2034** ENERGY AND ANGULAR DISTRIBUTIONS OF ELECTRONS EJECTED FROM HYDROGEN AND HELIUM BY 100- TO 300-keV PROTONS. Rudd, M. E.; Sauter, C. A.; Bailey, C. L. (Concordia Coll., Moorhead, Minn.). Phys. Rev., 151: 20-7 (Nov. 4, 1966).

Measurements were made of the differential cross sections for ejection of electrons of various energies at various angles from hydrogen and helium gases bombarded by 100- to 300-keV protons. After electrostatic analysis, individual electrons were counted using an electron-multiplier detector. Measurements were made at nine angles from 10° to 160° and at electron energies down to 2 eV. Comparison is made with Born-approximation calculations using hydrogen wave functions but with the results scaled to molecular hydrogen and to helium. The Gryziński classical theory is also used to calculate cross sections, and these are compared with the Born approximation and with the experimental values. A simple semi-empirical equation was found, which fits the energy distributions fairly well at low and intermediate energies. (auth)

**2035** ELECTRON ENERGY SPECTRUM FROM $Ar^+$–Ar AND $H^+$–Ar COLLISIONS. Rudd, M. E.; Jorgensen, T. Jr.; Volz, D. J. (Univ. of Nebraska, Lincoln). Phys. Rev., 151: 28-31(Nov. 4, 1966).

Absolute differential cross sections were measured for the ejection of electrons of various energies at 160° by argon ions and protons striking argon gas as a target. The observed energy spectrum consists of a number of "lines" or peaks superimposed on a continuous spectrum. The fine-structure regions occur below 20 eV and from about 120 to 220 eV for both projectiles. A number of lines are identified with autoionization transitions from neutral states and with Auger transitions from one- and two-vacancy states. With argon ions each peak has a "Doppler"-shifted counterpart due to electrons emitted from the moving particles. The data are compared with the Fano–Lichten electron-promotion model and with the statistical theories of Russek and of Everhart and Kessel. (auth)

**2036** MODIFIED OPTICAL-POTENTIAL APPROACH TO LOW-ENERGY ELECTRON-HELIUM SCATTERING. Pu, Robert T.; Chang, Edward S. (Univ. of California, Riverside). Phys. Rev., 151: 31-40(Nov. 4, 1966).

A modified optical-potential approach is introduced for electron-atom scattering at low energies whereby the formal optical potential is used directly in a variational expression for scattering phase shifts. This approach has the advantage that one may include the effect of the second-order optical potential without recourse to the usual adiabatic approximation. The diagrammatic approach associated with the present method makes it possible to identify different contributing terms with different physical effects, and thus to assess the relative importance of various physical effects involved in the scattering process. To test the approach as a practical method for low-energy electron–atom scattering, it was applied to the case of electron–helium scattering for the energy range 1.2 to 16.4 eV. Good agreement with available experimental data was obtained. The contributions of various multipole components in the second-order optical potential are examined. In particular, the effect of exchange in the second-order optical potential, neglected in most calculations, was found to be very significant. (auth)

**2037** RELATIVE ABUNDANCES OF IONS FORMED AS THE RESULT OF INNER-SHELL VACANCIES IN ATOMS. Carlson, Thomas A.; Hunt, W. E.; Krause, Manfred O. (Oak Ridge National Lab., Tenn.). Phys. Rev., 151: 41-7(Nov. 4, 1966). (ORNL-P-2243).

Relative abundances of differently charged ions were measured following the x irradiation of Xe and, in separate experiments, of Hg. These studies were carried out for a variety of x-ray energies in order to obtain data as a function of the initial inner-shell vacancies. From the data charge spectra that result from producing an initial vacancy in each of the following shells are derived: the K, $L_I$, $L_{II,III}$, $M_I$, $M_{II,III}$, $M_{IV,V}$, and N shells of Xe; and the L, M, N, and O shells of Hg. These data are correlated with earlier measurements on He, Ne, Ar, and Kr; and empirical rules are set up whereby one may estimate the average charge resulting from the atomic readjustment to a vacancy in any shell of any atom. (auth)

**2038** COMPARISON OF LOW-ENERGY TOTAL AND MOMENTUM-TRANSFER SCATTERING CROSS SECTIONS FOR ELECTRONS ON HELIUM AND ARGON. Golden, D. E. (Lockheed Palo Alto Research Lab., Calif.). Phys. Rev., 151: 48-51 (Nov. 4, 1966).

Modified effective-range theory has allowed an unambiguous extrapolation of recent total electron–atom and –molecule scattering cross sections to zero energy. This extrapolation completely determines the differential scattering cross section and therefore the momentum transfer or diffusion cross section for the range of applicability of the effective-range theory. Calculations of momentum-transfer cross sections derived from the total cross-section data of Golden and Bandel for the cases of He and Ar are presented and discussed. It is shown that diffusion cross sections obtained by unfolding swarm experiment data are inconsistent with diffusion cross sections obtained from total cross-section data using effective-range theory. (auth)

**2039** SCATTERING CROSS SECTIONS OF ARGON AND ATOMIC OXYGEN TO THERMAL ELECTRONS. Daiber, J. W.; Waldron, H. F. (Cornell Aeronautical Lab., Inc., Buffalo). Phys. Rev., 151: 51-5(Nov. 4, 1966).

The electron-scattering cross section for momentum transfer of several neutral species has been experimentally determined. An S-band microwave interferometer was employed to investigate the plasma produced by the incident shock wave in a shock tube. This plasma was in the state of equilibrium, so the relative species concentrations and the electron velocity distribution were known. For electron-collision frequencies small compared with the signal frequency, the microwave data could be interpreted to yield the scattering cross sections. The cross section of the argon atom was measured from 1800 to 5500°K. The results agree with previous drift measurements when those cross sections are averaged over the Maxwellian distribution of electron velocities. Above 3000°K the oxygen molecule becomes dissociated and the oxygen–atom cross section can be measured. From 3000 to 4000°K, this atomic cross section is $(1.2 \pm 0.2) \times 10^{-15}$ cm$^2$. For molecular nitrogen and oxygen the small-collision-frequency requirement

could not be fully satisfied. The cross sections for these gases were approximately $10^{-15}$ cm$^2$ from 2000 to 3500°K, with no observable dependency on gas density. (auth)

**2040** CHARACTERISTIC X-RAY PRODUCTION IN MAGNESIUM, ALUMINUM, AND COPPER BY LOW-ENERGY HYDROGEN AND HELIUM IONS. Brandt, Werner; Laubert, Roman; Sellin, Ivan (New York Univ., N. Y.). Phys. Rev., 151: 56-9(Nov. 4, 1966).

Comparative characteristic K x-ray yields in Mg and Al and L x-ray yields in Cu, produced by bombardment with singly charged ions of H, $^3$He, and $^4$He, are reported for particle energies ranging from 25 to 50 keV per amu. Characteristic x-ray production cross sections for the K-shell processes are extracted from these data and from previous proton work. The ratios of helium to proton cross sections at equal particle velocities are significantly smaller than expected from current theories. It is shown that the discrepancy can be fully accounted for by the effect on the cross section of the binding of the K-shell electrons to the projectile, which is in close proximity to the nucleus at the time of excitation. (auth)

**2041** EXCITATION OF THE SPIN MULTIPLETS OF THE GROUND STATE OF OXYGEN BY SLOW ELECTRONS. Breig, Edward L.; Lin, Chun C. (Univ. of Oklahoma, Norman). Phys. Rev., 151: 67-79(Nov. 4, 1966).

Electron excitation cross sections of the transitions between the three spin multiplets J = 0, 1, 2, of the $[(1s)^2(2s)^2(2p)^4]^3P$ ground state of the neutral oxygen atom have been calculated by using the continuous-state Hartree–Fock formulation for electron energies of 500 to 10,000°K. Partial-wave analysis is performed in a coupled representation characteristic of the total angular momentum of the entire system. The scattering equations are further simplified by neglecting the coupling between the different partial waves of the incident electron. Under an exact-resonance approximation, the scattering equations for the s wave can be completely decoupled and the solutions obtained by numerical iteration. The p-wave manifold consists of three sets of simultaneous equations. Exact solutions (close-coupling) are obtained for selected scattering equations and are compared with the corresponding collision strengths calculated by a modified distorted-wave treatment to examine the validity of the latter approximate method. Final collision strengths for the p wave are evaluated from appropriate combinations of the close-coupling and weak-coupling schemes. Partial cross sections for the d wave are found to be of minor importance and may be obtained with the Born approximation. Corrections for the energy differences between atomic states are found to be small. The calculated cross sections are somewhat larger than the values estimated by Gershberg and provide evidence for the importance of the role of neutral oxygen atoms in the cooling of the interstellar media. (auth)

**2042** $\pi^-$ CAPTURE IN HYDROGEN–DEUTERIUM AND HYDROGEN–HELIUM MIXTURES. Derrick, K.; Derrick, M.; Fetkovich, J. C.; Fields, T. H.; Pewitt, E. G.; Yodh, G. B. (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 151: 82-6(Nov. 4, 1966).

An experimental study was made of the effects upon the $\pi^-$ moderation process of deuterium and helium admixtures to liquid hydrogen. The effect of deuterium was studied by a counter measurement of the relative $\pi^0$ yield per stopping $\pi^-$ as a function of the deuterium concentration. It was found that the $\pi^0$ yield per stopping $\pi^-$ per unit hydrogen concentration remained equal to unity for atomic concentrations of deuterium less than ~10%, while at 50% concentration this yield was down by about 25%. If the atomic cascade time for $\pi^-$ in liquid hydrogen is $2.3 \times 10^{-21}$ sec, the net transfer rate for the reaction $(\pi^-p)^* + d \rightarrow (\pi^-d)^* + p$ must be about $6 \times 10^{11}$ sec$^{-1}$. This rate is for excited states of the $\pi$p and $\pi$d atoms, as the $\pi^-$ is believed to undergo nuclear capture upon reaching $n \approx 4$. To study the effect of helium, a negative pion beam was stopped in a bubble chamber containing about 1 at. % of helium dissolved in liquid hydrogen. The fraction of pions captured by helium was measured to be about 1%, indicating that the net transfer to helium was small at these concentrations. (auth)

**2043** COLLISIONAL EXCITATION OF NEON SPECTRA. Bashkin, S. (Univ. of Arizona, Tucson); Wangsness, R. K.; Heroux, L. Phys. Rev., 151: 87-96(Nov. 4, 1966).

Electronic spectra in Ne II, III, IV, V, VI, and VII were excited by sending a beam of 5.1-MeV $Ne^{2+}$ ions through a thin carbon foil. A number of discrete spectral lines were detected in the extreme ultraviolet, the wavelength range studied being between 250 and 1300 Å. It appears that D terms are populated most, S terms hardly at all, and P terms to an intermediate amount. Mean lives of levels in Ne IV and Ne VI were measured. A general discussion is given of the fast-beam-and-foil technique for exciting spectral lines. (auth)

**2044** THEORY OF THE (NORMAL) GROUND STATE OF LIQUID $^3$He. Woo, Chia-wei (Washington Univ., St. Louis). Phys. Rev., 151: 138-52(Nov. 4, 1966).

A theory of the normal ground state of liquid $^3$He is constructed using matrix elements in a representation of correlated basis functions. The Rayleigh–Schrödinger perturbation theory is adapted to the nonorthogonal basis. Several means of classifying terms are available; one of them is recognized as best suited for the study of liquid $^3$He. To the second order in the classification scheme, the following ground-state properties are calculated and compared with experiment and results of the Brueckner–Gammel theory: energy per particle, equilibrium density, compressibility, velocity of sound, and paramagnetic susceptibility. The radial distribution function of liquid $^3$He at zero temperature is also calculated. A study of the Löwdin transformation as a procedure for orthogonalizing the correlated basis shows that the correction to the Hamiltonian involves unphysical N dependences; these arise out of high-order irreducible clusters and unlinked diagrams. It is verified that the unphysical terms cancel out completely in each of several lowest orders. (auth)

**2045** GROUND STATE OF LIQUID HELIUM: BOSON SOLUTIONS FOR MASS 3 AND 4. Massey, Walter E. (Washington Univ., St. Louis). Phys. Rev., 151: 153-64(Nov. 4, 1966).

The ground-state properties of a system of liquid $^4$He and of an artificial mass-3 boson system are calculated by a variational procedure employing a Jastrow-type trial wave function in conjunction with the Kirkwood superposition approximation for the three-particle distribution function. The parameters in a Lennard–Jones 6–12 potential are determined in a self-consistent manner and the energy, pressure, velocity of sound, pair-distribution function, and liquid-structure function are calculated as functions of density. The agreement between the theoretical and experimental results is good. (auth)

**2046** DECAY FEATURES OF POSITRONS IN SEMICONDUCTORS. Fabri, G.; Poletti, G.; Randone, G. (Centro Informazioni Studi Esperienze, Milan). Phys. Rev., 151: 356-9 (Nov. 4, 1966).

Positron lifetime measurements in some typical semiconductors are reported. In every case the decay displays two components, the longer one being of the order of $\tau_2 = 10^{-9}$ sec and having an intensity of a few percent. Measurements on neutron-damaged samples show that both components are sensitive to the presence of lattice defects. Moreover, at least in the case of silicon, the long-lifetime component is lacking when a high electric field is applied to the sample. The presence of a high oxygen concentration in gallium arsenide and in silicon is effective in preventing annihilations through the $\tau_2$ lifetime. (auth)

**2047** GROUND-STATE PROPERTIES OF A MODEL OF A TWO-DIMENSIONAL SYSTEM OF LIQUID $^3$He. Anderson, Roger H. (Seattle Pacific Inst. for Research); Foster, Theodore D. Phys. Rev., 151: 190-5(Nov. 4, 1966).

An investigation is made of the low-temperature behavior of a two-dimensional many-fermion system parametrized to serve as a model of a monomolecular layer of liquid $^3$He. The calculations are made using the $\Lambda_{00}$ approximation of the Martin–Schwinger thermodynamic Green's function theory. A Herzfeld potential is used for the two-body interaction in order that the resulting T-matrix equation can be solved exactly. Three sets of the three parameters of this potential are chosen by requiring that they reproduce either the experimental and theoretical low-temperature second virial coefficient, the phase shifts calculated from the 6–12 potential, or the experimental binding energy and density of the three-dimensional system. The chemical potential, energy per particle, density, and specific heat are calculated. Of the three sets of parameters the maximum binding energy for the two-dimensional system results from the potential that predicts the correct three-dimensional experimental energy and density. The maximum binding in this case is 0.68°K at a density corresponding to $r_0 = 2.9$ Å. Three-dimensional calculations were made with the several sets of parameters, with the result that the virial-coefficient and phase-shift sets predict too little attraction. (auth)

**2048** OBSERVATION OF THE FIELD-DEPENDENT RAMSEY RESONANCE WITHOUT EXTREMELY HOMOGENEOUS MAGNETIC FIELDS. Chan, Y. W. (Brookhaven National Lab., Upton, N. Y.). Phys. Lett., 23: 447-8(Nov. 14, 1966).

The necessary condition for observation of a Ramsey resonance is given for atoms traversing a quite inhomogeneous magnetic field. The application to a field-dependent transition is demonstrated for $^{39}$K atoms in a magnetic field with variations >0.1 G Several applications of the technique are suggested. (auth)

**2049** INTERPRETATION OF CHARACTERISTIC ENERGY LOSSES IN ATOMIC COLLISIONS. Nikulin, V. K. (Ioffe Inst.

of Physics and Tech., Leningrad). Phys. Lett., 23: 452-3 (Nov. 14, 1966).

The first peak in characteristic energy losses in $Ar^+ - Ar$ collisions is explained by autoionizing states of the compound molecular ion $Ar_2^+$. (auth)

**2050** NEW MANUFACTURING TECHNIQUE FOR THE PRODUCTION OF THIN FILMS BY SPUTTERING. Gaydou, F. Vakuum-Tech., 15: 161-4(Sept. 1966). (In German).

This technique uses sputtering by argon ions from an extraneously produced plasma. By means of a new arrangement of the anode and the materials to be sputtered one attains ion currents up to 2 A in the $10^{-4}$ torr range. A sputtering rate, high enough to produce thin films in series is yielded. Reactive sputtering is possible too. (auth)

**2051** TRANSPORT AND IONIZATION PROPERTIES OF MOLECULAR GASES IN A TRANSVERSE MAGNETIC FIELD. Fletcher, J.; Haydon, S. C. (Univ. of New England, Armidale, New South Wales). Austral. J. Phys., 19: 615-28(Oct. 1966).

Measurements are reported of pre-breakdown ionization in E × B fields under conditions that permit unrestricted motion of the electrons in the E × B direction. These measurements have been carried out in a coaxial cylindrical ionization chamber, details of which are given. An alternative method of examining the development of ionization as a function of pressure has been used, and a comparison is made of the results of such investigations with earlier spatial measurements using plane geometry. The use of an electromagnet capsule of producing magnetic fields up to 10,000 G substantially uniform over the required constant annular gap spacing has permitted an extension of earlier work to the "strong" magnetic field limit, i.e., values of $B/p \simeq 2500$ G/torr(0°C). Details of measurements made in the molecular gases $H_2$ and $N_2$ are given. (auth)

**2052** DRIFT VELOCITY OF ELECTRONS IN CARBON DIOXIDE AT 293 DEG K. Elford, M. T. (Australian National Univ., Canberra). Austral. J. Phys., 19: 629-34(Oct. 1966).

The drift velocity of electrons in carbon dioxide at 293°K has been measured with an error of less than 0.5% over the range $0.3 \times 10^{-17}$ V cm$^2$ < E/N < $9.1 \times 10^{-17}$ V cm$^2$ and 1% over the range $9.1 \times 10^{-17}$ V cm$^2$ < E/N < $21.2 \times 10^{-17}$ V cm$^2$. The accuracy of the available data is discussed. (auth)

**2053** LIMITING BEHAVIOR OF THE ABSORPTION CROSS SECTIONS OF THE NEGATIVE HYDROGEN ION. John, T. L. (University Coll., Cardiff, Wales). Mon. Notic. Roy. Astron. Soc., 133: 447-8(1966).

The threshold behavior of the bound–free transitions of $H^-$ and the differences between the calculations of Geltman and Doughty and Fraser are discussed. A simple formula and table to calculate the free–free cross section accurately for wavelengths greater than 10,000 Å are given. (auth)

**2054** THEORY OF THREE-PARTICLE SYSTEMS WITH COULOMB EXCHANGE FORCES. II. EXCITED VIBRATIONAL STATES. Dreher, R.; Schroeder, U. (Univ., Frieburg i. B.). Z. Phys., 197: 192-6(1966). (In German).

Extending the results of a preceding paper (Z. Physik, 173: 221 (1963)) the excited vibrational states of the $H_2^+$ ion are calculated. An improved Born–Oppenheimer approximation was used in the calculations. (auth)

**2055** SOME PHYSICAL ASPECTS OF SPUTTERING. Rol, P. K.; Onderdelinden, D.; Kistemaker, J. (FOM Laboratory for Mass-Separation, Amsterdam). pp 75-82 of 1965 Transactions of the Third International Vacuum Congress. Vol. I. Adam, H. (ed.). New York, Pergamon Press, 1966.

A survey of some physical aspects of cathode sputtering due to the impact of energetic positive ions on metal surfaces is given. Fundamental studies in the use of ion beam techniques, single crystalline targets, and the application of electronic computers is described. The removal of surface atoms by impulse transfer mechanisms is discussed. Only a small fraction of the sputtered particles escapes by evaporation. The transparency model for single crystal sputtering explains the experimental results for face-cubic-centered crystals fairly well. The mean energy of the escaping surface material depends on the energy of the colliding primary ion. About 1% of the sputtered particles can be ionized in case of high energy bombardment. Photons are also observed. Gas injection into a surface is discussed, as well as the influence of the temperature on this process. Bubble formation occurs at 350°C in Cu targets. At an injection energy of 45 keV, saturation values equivalent up to 20 mono layers have been observed. Surface etching, and creation of irregularities like pyramids are due to different crystal orientations and dust particles. Surface compositions can be changed by bombardment. (auth)

**2056** MASS 1 PEAK IN IONIZATION SOURCES AT VERY LOW PRESSURES. Hobson, J. P.; Earnshaw, J. W. (National Research Council, Ottawa). Can. J. Phys., 44: 2531-2(Oct. 1966). (NCR-9158).

In addition to the dissociation of gaseous hydrogen by electrons, three proposed mechanisms exist describing the origin of atomic hydrogen in ionization sources utilizing incandescent filaments at very low pressures. A large mass-1 peak was observed in an ultrahigh vacuum system made predominantly of aluminosilicate glass. The mass spectrometer contained a simple ionization source with a molybdenum cage anode and two filaments (tungsten and thoria-coated iridium). Experiments seeking the origin of the high mass-1 peak led to the conclusion that it originates from hydrogen dissolved in the filament being used. (W.D.M.)

**2057** SENSITIVITY OF ATOMIC INTERACTION POTENTIALS TO DETAILS OF THE ELECTRON DISTRIBUTION. Wedepohl, P. T. (Univ. of Witwatersrand, Johannesburg). Solid State Commun., 4: 479-81(Sept. 1966).

Interaction energies as a function of internuclear separation were computed for two argon atoms. Use of electron densities obtained from self-consistent field calculations gives appreciably higher interaction energies than those obtained from Thomas–Fermi–Dirac densities. (auth)

**2058** DIELECTRIC CONSTANT OF $UO_2$ AND ITS VARIATION WITH POROSITY. Huntley, D. J. (Simon Fraser Univ., Burnaby, B. C.). Can. J. Phys., 44: 2952-6(Nov. 1966).

An experimental determination of the variation of the effective dielectric constant of sintered $UO_2$ with porosity was made and compared with theoretical predictions. The static dielectric constant of $UO_2$ is 21.7 ± 0.5 at 78°K and is consistent with the value predicted from the optical dielectric constant and optic phonon frequencies. (F.S.A.)

**2059** ELECTRON FOCUSING IN THIN SINGLE-CRYSTAL COPPER FILMS. Grachev, B. D.; Komar, A. P.; Korobochko, Yu. S.; Mineev, V. I. (Leningrad Polytechnic Inst.). (JETP Lett. (Engl. Transl.), 4: 163-4(Oct. 1, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 4: 241-3(Oct. 1, 1966).

The yield of K shell radiation from a thin (400 to 600 Å) single-crystal film of copper bombarded with 20 to 60 keV electrons was investigated with an electronograph. The relative increase in the K radiation reached 15 to 20%. These results are compared with proton channeling in such a crystal. (M.H.R.)

**2060** CONFIGURATION INTERACTION WAVEFUNCTION FOR POSITRONIUM HYDRIDE. Ludwig, Oliver G. (Univ. of Notre Dame, Ind.); Parr, Robert G. Theoret. Chim. Acta, 5: 440-5(1966).

A configuration interaction wavefunction is obtained for the pseudo-atom positronium hydride (consisting of one proton, one positron, and two electrons), using Slater orbitals centered on the proton as basis functions. A positive dissociation energy is calculated for the process $PsH \rightarrow Ps + H$. Comparison is made with previous calculations of this energy, and its actual value is predicted to be 0.009 au. The two-quantum annihilation rate is calculated. The calculation gives for the ratio of rates 0.78 for the integer function and 0.83 for the non-integer function. The earlier calculation of Neamtan et al. gave 0.247, presumably closer to the correct value because of the better description of the positron-electron motion. Yet, improvement of the description of electron-electron correction in the function used earlier would be expected to increase the value of the ratio. (BBB)

**2061** DEUTERON MAGNETIC RESONANCE ABSORPTION IN POLYCRYSTALLINE HEAVY METHANE BETWEEN 1.4 AND 73°K. Pyykooe, P. (Univ. of Turku, Finland). Phys. Lett., 23: 296-7(Oct. 31, 1966).

The deuteron magnetic resonance line width and second moment in polycrystalline heavy methane were measured between 1.4 and 73°K. Below the line width transition, caused by diffusion, the observed quantities stayed essentially constant to the lowest temperature investigated. A qualitative interpretation is given. (auth)

**2062** AUTOIONIZATION RATES OF $N^{4+}$ AND $O^{5+}$ IN THE (1s, 2s, 2p)$^4P_{5/2}$ STATE. Manson, S. T. (Columbia Univ., New York). Phys. Lett., 23: 315-16(Oct. 31, 1966).

The autoionization rates of $N^{4+}$ and $O^{5+}$ in the (1s, 2s, 2p) $^4P_{5/2}$ state are calculated using separable variational wave functions and the results are compared with experiment. (auth)

**2063** ON THE MECHANISM OF SCINTILLATION OF HELIUM, HELIUM–ARGON, AND HELIUM–NEON MIXTURES INDUCED BY ALPHA IMPACT. Takahashi, T. (Inst. of Physical and Chemical Research, Tokyo); Kubota, S.; Doke, T. Phys. Lett., 23: 321-2(Oct. 31, 1966).

The scintillation of helium is explained by de-excitation of the excited molecule formed by a three-body collision of a metastable atom with ground state atoms. (auth)

**2064** RESONANCES IN THE ELASTIC SCATTERING OF ELECTRONS BY HYDROGEN ATOMS. Aronson, Irving. New York, New York Univ., 1965. 77p.

Thesis.

A projection operator formalism is applied to the study of resonances occurring in the scattering of electrons by atomic hydrogen at energies below the excitation threshold. The exact resonance energies are shown to be the discrete eigenvalues of a modified Hamiltonian. This Hamiltonian requires the knowledge of the Green's function of the static one-body equation. An expression for the static Green's function is obtained which involves functions which are the solutions of integral equations. Numerical procedures are presented for solving these equations. The s wave (L = 0) triplet state presents difficulties because of the existence of a homogeneous solution, and methods are developed for dealing with this problem. Expressions are also derived for the resonance half-widths and shifts, which only involves quantities which can be explicitly obtained. Properly symmetrized trial functions, expanded in angular momentum states l of the target atom and containing nonlinear parameters, are introduced. Matrix elements of the Hamiltonian for L = 0 and l = 0 to 4 and for the explicit 2s state of the target, which can be used in a Hyleraas–Undheim type variational calculation to obtain the resonance parameters, are evaluated. (Dissertation Abstr.)

**2065** AN EXPERIMENTAL STUDY OF NEGATIVE ION CHARGE TRANSFER REACTIONS. Rundel, Robert Dean. Seattle, Univ. of Washington, 1965. 86p.

Thesis.

Charge transfer cross sections for atomic negative ions incident on neutral molecular targets have been measured over an energy range of 200 to 3000 eV, using a modulated crossed-beam apparatus. The reactions studied were: $H^- + O_2 \rightarrow H + O_2^-$; $O^- + O_2 \rightarrow O + O_2^-$; $H^- + NO_2 \rightarrow H + NO_2^-$; $O^- + NO_2 \rightarrow O + NO_2^-$; and $O^- + H_2 \rightarrow O + H^- + H$. Mass analysis of the secondary ions produced in the collision was accomplished by means of a crossed electric and magnetic field analyzer, in order to identify unambiguously the reaction products. It is shown that the energy defect used in the adiabatic model of atomic collisions should have a polarization correction because of the attractive induced dipole force between an ion and a neutral particle, and that this correction is particularly important for negative ion charge transfer because of the characteristically small binding energy of the extra electron on the negative ion. When this correction is applied to the energy defect, the predictions of the adiabatic model are consistent with the results of the present experiment. Further experiments are suggested to continue the study of negative ion charge transfer. (Dissertation Abstr.)

**2066** SPECTRUM OF DOUBLY IONIZED SAMARIUM. Dupont, Andre Armand. Baltimore, Johns Hopkins Univ., 1966. 91p

Thesis.

The emission spectrum of samarium was photographed under varied source conditions from 1800 to 9900 Å in order to obtain a description of the spectrum of doubly ionized samarium. The resulting line list contains 19,000 lines, of which 15,000 are attributed to Sm III. A search was made for quantum levels by the method of common differences. The analysis was fruitful for the ground multiplet $4f^6(^7F)$ and for seven septets of the $4f^5 5d$ configuration, which have been partially determined. In all, forty-two levels were found, resulting in the classification of 100 lines. Attempts to determine the quintets levels of the $4f^5 5d$ configuration and the levels of the $4f^5 6p$ and $4f^5 6s$ configurations were unsuccessful, mostly because of the large number of accidental coincidences. The theoretical calculation of the $4f^5 5d$ configuration indicated well developed L–S coupling. (Dissertation Abstr.)

## Cosmic Radiation

*Refer also to abstracts 1577, 1590, and 1996.*

**2067** GREEN FUNCTION FORMULATION OF THE DIRAC FIELD IN CURVED SPACE. Islam, J. N. (Cambridge Univ., Eng.). Proc. Roy. Soc. (London), Ser. A., 294: 437-48(Oct. 18, 1966).

A Green function formulation of the Dirac field in curved space is considered in the cases where the mass is constant and where it is regarded as a direct particle field in the manner of Hoyle & Narlikar (1964 c). This description is equivalent to, and in some ways more satisfactory than, that given in terms of a suitable Lagrangian, in which the Dirac or the mass field is regarded as independent of the geometry. The essential idea is to define the Dirac or the mass field in terms of certain Green functions and sources so that the field equations are satisfied identically, and then to obtain the contribution of these fields to the metric field equations from the variation of a suitable action that is defined in terms of the Green functions and sources. (auth)

**2068** ATMOSPHERIC WATER VAPOR AND ATTENUATION OF THE COSMIC-RAY NUCLEONIC COMPONENT. Chasson, R. L.; Kisselbach, V. J.; Sharma, T. C. (Univ. of Denver). J. Geophys. Res., 71: 5183-4(Nov. 1, 1966).

Experimental results are presented that indicate that the barometric pressure coefficient customarily employed to correct terrestrial neutron monitor intensities is subject to variations in magnitude that are apparently related to changes of atmospheric water vapor content above the site of measurement. (J.H.M.)

**2069** ENERGY DEPENDENCE OF THE ISOTOPIC COMPOSITION OF HELIUM NUCLEI IN THE PRIMARY COSMIC RADIATION. Badhwar, G. D.; Kaplon, M. F. (Univ. of Rochester, N. Y.). J. Geophys. Res., 71: 5175-8(Nov. 1, 1966).

Taking into account the ionization loss, fragmentation, and modulation, the energy dependence of the ratio $^3He/(^3He + ^4He)$ is calculated. A comparison of the results with experimental values indicates that the primary radiation has traversed 2.5 to 3.0 g $cm^{-2}$ of hydrogen. It is concluded that the above energy dependence can be adequately explained when it is assumed that all $^3He$ nuclei are of secondary nature and when the ionization loss and modulation are properly taken into account. The results indicate that: (1) the exponent of the $^3He$ nuclei differential energy spectrum calculated for 2.5 g $cm^{-2}$ of traversed hydrogen between 30 to 90 MeV/n of +3.2 is in good agreement with previous measurements, and (2) the combined agreement of the calculated spectral index and the calculated $^3He/(^3He + ^4He)$ ratio for a traversal by cosmic radiation of 2.5 g $cm^{-2}$ of path length and ionization length lends support to the assumption that the primary cosmic radiation has traversed 2.5 g $cm^{-2}$ of hydrogen irrespective of its energy. (J.H.M.)

**2070** RECURRENT FORBUSH DECREASES ASSOCIATED WITH M-REGION MAGNETIC STORMS. McCracken, K. G.; Rao, U. R.; Bukata, R. P. (Southwest Center for Advanced Studies, Dallas). Phys. Rev. Lett., 17: 928-32(Oct. 24, 1966).

Observations are reported of a number of recurrent cosmic-ray modulation phenomena which have all the characteristics of Forbush decreases, but which were not preceded by solar flares. They are correlated with M-region magnetic storms, and it is concluded that each recurrent series is the result of a shock wave initiated by a continuous emission of fast plasma by a restricted area of the sun. (J.H.M.)

**2071** COSMIC ELECTRONS ABOVE 10 GeV AND THE UNIVERSAL BLACK-BODY RADIATION AT 3 DEG K. Daniel, R. R.; Stephens, S. A. (Tata Inst. of Fundamental Research, Bombay). Phys. Rev. Lett., 17: 935-9(Oct. 24, 1966).

Observations made on cosmic-ray electrons based on 28 events are used to construct a differential energy spectrum between about 12 and 350 GeV with a statistical accuracy sufficient enough to draw some meaningful conclusions about the universal black-body radiation at 3°K. Results indicate that there is reason to doubt the existence of the universal black-body radiation at 3°K if the galactic halo model used in this study is correct. (J.H.M.)

**2072** MECHANISM OF DIURNAL VARIATIONS IN COSMIC RAYS. Stepanyan, A. A. Izv. Krymsk. Astrofiz. Observ., 32: 56-66(1964). (In Russian).

It is shown that the main characteristics of the diurnal effect in cosmic rays (variation spectrum and latitude variations of the first and second harmonic) can be explained if it is assumed that the diurnal variation is due to the action of an electric field. The absence of variations in the region of small energies (1 to 10 BeV) can be explained by the scattering of cosmic rays on magnetic clouds with a chaotic field. (auth)

**2073** ORIGIN AND PROPERTIES OF THE COSMIC-RAY RIGIDITY SPECTRUM. Skadron, George. Rochester, N. Y., Univ. of Rochester, 1966. 247p.

Thesis.

A model is proposed to explain a number of the features of the differential rigidity spectra of the nuclear components of the primary cosmic radiation. It is assumed that a supernova explosion results in the acceleration of nuclei to a pure power law rigidity spectrum and a composition relatively rich in heavy and medium weight nuclei. The supernova remnant into which these particles are injected is characterized by large scale trapping regions resulting from predominantly closed magnetic field lines which partially isolate the region from the surrounding galactic space. This feature of the supernova region is represented by a dipole-like field whose strength is such that the dipole field merges

smoothly into the galactic field (assumed quasi-uniform) at a distance comparable to the radius of the Crab Nebula. Superimposed on this field it is assumed that there are magnetic irregularities which produce a certain amount of distortion of the field lines in the interior of the source. It is further proposed that irregularities in the magnetic field along the periphery of the source lead to local distortions of the field and hence, a mixing of galactic and source field lines in the neighborhood of these irregularities. (W.D.M.)

## Direct Energy Conversion

*Refer also to abstracts 2212 and 2271.*

**2074** (AD-631005) NON-EQUILIBRIUM IONIZATION USING ELECTROSTATIC PROBING TECHNIQUES. Final Technical Report, March 1, 1965–February 28, 1966. Bullis, Robert H.; Wiegand, Walter J.; Bell, Donald W. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Mar. 30, 1966. Contract AF 49(638)-1551. 78p. (AFOSR-66-0633). CFSTI $7.60 cy, $0.75 mn.

The results of the research program were the determination of the effects of the presence of various inert background gases on the electron energy distribution, electron number density, and potential variation in the plasma of a cesium ignited-mode thermionic converter. Plasma properties are reported for a number of different ratios of inert gas background pressure to cesium pressure for the addition of inert species of xenon, krypton, and neon gases. The results are related to the transport and ionization processes taking place in the ignited-mode converter through the use of recently available electron–cesium heavy particle cross-section information as well as the detailed information on the plasma properties obtained from the investigations reported in AD-621 276. In conjunction with the electrostatic probe measurements, spectroscopic investigations were conducted to determine the number density of electrons existing in the plasma. Also included is a summary of the overall accomplishments resulting from these investigations and a bibliography of the publications generated as a result of this study. (auth)

**2075** (ANL-7148) CHANNEL-WALL LIMITATIONS IN THE MHD INDUCTION GENERATOR. Pierson, Edward S.; Jackson, William D. (Argonne National Lab., Ill.). Mar. 1966. Contract W-31-109-eng-38. 55p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Materials problems influencing the design and performance of the MHD induction generator are discussed. The previous analysis of the machine is reviewed and extended to include electrically-conducting channel walls and thermal insulation. The infinite-length machine is examined in detail, including both an approximate analysis to show the general behavior, and an exact solution to provide numerical data. The power flow between the field structure and the fluid is used to determine the effect of the conducting wall with practical material properties and machine dimensions. It is shown that the wall thickness has to be very small for acceptable generator performance, and that this requirement raises severe structural problems. The effect of the insulation is determined to be small. By means of an approximate solution, the previous analysis of the finite-length machine is also extended to include walls and insulation. (auth)

**2076** (NYO-3642-3) THE DEVELOPMENT OF AN ADSORPTION CESIUM RESERVOIR. Third Quarterly Technical Report. (Radio Corp. of America, Lancaster, Pa. Direct Energy Conversion Dept.). Sept. 1966. Contract AT(30-1)-3642. 37p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

In developing an adsorption cesium reservoir for a thermionic converter, progress is reported on: (1) the testing of converters with external adsorption reservoirs; (2) the testing of converters with internal adsorption reservoirs; and (3) the modification of converters with internal adsorption reservoirs for life tests. Information is included on the characteristics of reservoir materials and structures. Thermal data obtained during the tests were useful in completing the design of a converter with an automatic, internal, cesium adsorption reservoir. The test apparatus is described, and test procedures are discussed. (J.H.M.)

**2077** (TID-23318, pp 173-86) ENERGY CONVERSION RESEARCH. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

An initial feasibility study was conducted on the advantages of an MHD conversion system for marine use. A gas Brayton cycle and one example of a liquid-metal Rankine cycle were used; required were a power output of 11 MW and a reactor capable of transmitting a temperature of 1500°K to the cooling fluid. Analyses are briefly described and results are given. As a first step in the study of the mist-flow MHD induction machine, the interaction between a rigid conducting sphere and a traveling magnetic field was considered. The status of research on alkali-metal vapor MHD generators is briefly reviewed. Convenient stability criteria for magnetoacoustic waves in the two-temperature conduction regime were developed. (W.D.M.)

**2078** AN ANALYSIS OF NON-UNIFORM PROTON IRRADIATION DAMAGE IN SILICON SOLAR CELLS. Crowther, D. L.; Lodi, E. A.; DePangher, J.; Andrew, A. (Lockheed Missiles and Space Co., Palo Alto, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-13: No. 5, 37-46 (Oct. 1966).

Experimental data obtained on the degradation of the short-circuit current in 1-ohm-cm N/P silicon solar cells irradiated by low-energy, 0.1 to 3.0 MeV, protons were analyzed with the aid of an N-layer solar-cell model. The results show that the damage constant, $K(E_p)$, rises less rapidly with decreasing proton energy, $E_p$, than it does at higher proton energies. The derived damage law can be analytically described as follows:

$$K(E_p) = \begin{cases} K_0 e^{-C_1 E_p} & E_p \le E_1 = .962 \text{ MeV} \\ K_0 e^{-C_1 E_1} \left(\dfrac{E_p}{E_1}\right)^{-C_2} & E_1 \le E_p \le 2.98 \text{ MeV} \end{cases}$$

where $K_0 = 1.92 \times 10^{-5} p^{-1}$, $C_1 = 1.08$ MeV$^{-1}$, and $C_2 = 0.85$. This representation has been found adequate for incident proton energies of 0.5, 1, and 3 MeV and definitive for $E_p \ge 0.1$ MeV. The value of $K_0$ listed should be considered as representative only of the particular solar cells analyzed. (auth)

**2079** THERMODYNAMICS OF CYCLES WITH MIXED LIQUID METAL IN FRONT OF MHD TRANSFORMER. Kalafati, D. D.; Kozlov, V. B. (Krzhizhanovskii Inst. of Power Engineering, USSR). Teplofiz. Vysok. Temp., 4: 424-8(May-June 1966). (In Russian).

Reversible and irreversible thermodynamic cycles were constructed in the $I_s$ diagram for mixed liquid metals in front of an MHD converter. Formulas were derived for the thermal efficiency of the reverse cycle in MHD conversion and for the thermal efficiency as a function of a saturation temperature at the inlet and outlet of the nozzle, and the initial water content in a vapor. The maximum electric efficiency in the high-water content vapor at the reactor outlet was found. The generally low energy coefficient of the cycle was due to shock losses during mixing. Thus, it was found that the scheme demanding mixing of a single-component working material in front of the MHD converter is not efficient, and should be replaced by another scheme or by different mixing process. (R.V.J.)

**2080** THE PERFORMANCE OF A THERMIONIC CONVERTER IN A CESIUM–NEON MIXTURE. Bekmukhambetov, E. S.; Guskov, Yu. K.; Lebedev, S. Ya. Teplofiz. Vysok. Temp., 4: 454-6(May-June 1966). (In Russian).

The results are presented of an investigation into the influence of a cesium–neon mixture on the performance of a thermionic converter. The measurements were made on an experimental lamp with plane electrodes. The dependence of the short-circuit current (I) on the cathode temperature was established together with the volt–ampere characteristics at different temperatures of the cathode in pure cesium vapors. Analogous series of measurements were made at different additions of neon. Two graphs presented show I as a function of cathode temperature at cesium vapor pressures of $2.8 \times 10^{-1}$ and 2 mm Hg, and with neon pressure from 0.27 to 39 mm Hg. The graphs show that the experimental value of I for pure cesium in a diffusion-equilibrium region agrees satisfactorily with the calculations made on the basis of the diffusion theory. The introduction of neon leads to a parallel shift of the curves toward smaller voltages. In an arc mode the short-circuit currents also decrease. Two other graphs show the volt–ampere characteristics at cathode temperatures from about 1470 to 1900°K for cesium pressures of $2.8 \times 10^{-1}$ and 2 mm Hg, respectively, for pure cesium, and at neon pressures of 0.27, 0.71, 3.37, and 39 mm Hg for a cesium–neon mixture. (ATD)

**2081** SEGMENTED ELECTRODE LOSSES IN MHD GENERATORS WITH NONEQUILIBRIUM IONIZATION. Kerrebrock, Jack L. (Avco-Everett Research Lab., Everett, Mass.). AIAA (Amer. Inst. Aeronaut. Astronaut. J., 4: 1938-47 (Nov. 1966).

The electrode losses in MHD generators designed to produce nonequilibrium ionization by electron heating appear to be qualitatively different from the losses in equilibrium generators because of the coupling between the conductivity and the local dissipation. A theory that accounts for this coupling is proposed. It predicts two possible modes of operation. In the "normal mode," which occurs at low values of the ideal electron temperature rise, the generator yields a large fraction of the ideal electron tempera-

ture rise. In the "shorted mode," which occurs at large values of ideal electron temperature rise, a layer of highly conducting gas is formed at the electrode wall by the electrode dissipation and supported by the Hall current that flows in the layer. In this mode the performance of the generator is greatly reduced. There is reasonable agreement between the performance predicted by the theory and that of two generators, one of which apparently operated in the normal mode, and the other in the shorted mode. It is concluded from the theory that electrode wall cooling and rather coarse electrode segmentation are beneficial in nonequilibrium generators. (auth)

**2082** VELOCITY ACHIEVEMENT IN ELECTRIC ARC-JET ENGINES. Kruelle, Gerhard; Huegel, Helmut (Institut fuer Plasmadynamik, Stuttgart). Z. Flugwiss., 14: 323-33(July 1966). (In German).

The exhaust velocity of continuously operating electric arc-jet engines may be considerably increased by electromagnetic forces. The effect of self-magnetic Lorentz forces on the features of supersonic flows is discussed. With $H_2$ as a working gas, mean velocities of up to 50,000 m/sec may be obtained. These are measured by a thruster in which the plasma is also accelerated by Hall effects. Data are presented for combustion chamber pressure of the engine as a function of mass throughput and current strength, voltage in the jet as a function of throughput and current strength, dependence of the Mach number on throughput and current strength, comparison of streaming processes as a function of Mach number and expansion ratio, thrust as a function of current strength with self-magnetic acceleration, and as a function of magnetic field strength and mass throughput, and plane voltage as a function of magnetic field strength and throughput in Ar. Several illustrations of the construction of the engine and of the form of radiation are given. (BBB)

**2083** ENERGETICS 6: MAGNETOHYDRODYNAMIC POWER. Mattsson, A. C. J.; Ducharme, E. L.; Govoni, E. M.; Morrow, I. B. Jr.; Brogan, T. R. (AVCO-Everett Research Lab., Everett, Mass.). Mech. Eng., 88: No. 11, 38-41(Nov. 1966).

A prototype rocket-driven self-excited MHD generator (Mark V) designed for a net power output of 20 MW is described. The generator has been tested over a wide range of operating conditions and has produced a maximum net power of 23.6 MW, with a gross power output of 32 MW. The main components of the Mark V are the combustion chamber, MHD channel, and self-excited air core field magnet. The sequence of operation is given and design factors are discussed. (W.D.M.)

**2084** THERMIONIC ENERGY CONVERSION: ALKALINE EARTHS AND CESIUM VAPORS. Psarouthakis, Ioannis. College Park, Md., Univ. of Maryland, 1965. 152p.

Thesis.

A theoretical and experimental investigation on thermionic energy conversion was conducted for the primary purpose of inventing a method which would enable a thermionic converter to operate free of nonessential limitations observed in present day thermionic converters. The theoretical study points out the fundamental limitations inherent to the process of thermionic emission and subsequently depicts the severe limitations imposed on the converters by presently used techniques. A thermionic converter, utilizing a high pressure cesium vapor, operates with a nonessential loss of at least 0.5 volt due to transport effects. This limits the output voltage to about half of what the converter is capable of producing. Further, the high vapor pressure generates a diffusion barrier due to electron collisions with the vapor atoms, thus limiting the output current to considerably smaller values than those emitted from the emitter. The theory shows that the detrimental effects are due to the duality in the use of the cesium-filled converters. There the cesium is used to reduce the emitter work function and at the same time generate ions for electron space charge neutralization. When cesium alone is used, very high vapor pressures are needed to reduce the bare work function of the emitter to levels allowing large electron emissions. In other words, the cesium vapor is not the best for emitter work function modifications. Other vapors might be more appropriate. However, cesium has the lowest ionization potential of stable substances that are known today. Therefore, cesium should be used for ion generation only, when possible, in a thermionic converter. A thermodynamic analysis on adsorption has shown that for the same degree of emitter work function reduction an alkaline-earth requires a vapor pressure of two orders of magnitude smaller than the corresponding pressure required by cesium. This analytical result and the fact that cesium has a low ionization potential lead to the concept of using an alkaline-earth vapor to modify the emitter work function and cesium to generate ions only. This vapor combination should result in a low vapor pressure operation free of gross transport affected losses, thus achieving high performance limited only by the fundamental and necessary emission processes. A flat plate electrode converter with variable interelectrode spacing was built incorporating independently controlled barium and cesium reservoirs; this converter was tested and provided data verifying the theoretical predictions. Fundamental conversion efficiencies of 27% independent of spacing were obtained at 2000°K emitter temperature and at an output voltage of 0.9 volt as compared to 15% and 0.5 volt at the same temperature when cesium is used and the interelectrode spacing is kept very small. At larger spacings the difference is even greater. (Dissertation Abstracts)

**2085** ELECTRICAL CHARACTERISTICS OF SILICON SOLAR CELLS AT LOW TEMPERATURES. Kennerud, Kenneth L. (Boeing Co., Seattle). 15p. (CONF-660719-1). ORAU. Gmelin, AED-CONF-66-235-1.

From IEEE Aerospace Systems Conference, Seattle.

Experimentally determined values of open circuit voltage, short circuit current and maximum power for p-n and n-p silicon solar cells are presented for temperatures ranging from −196°C to +50°C under equivalent space sunlight intensities of 58 milliwatts per square centimeter and 268 milliwatts per square centimeter. An anomalous behavior is observed in the n-p cells at low temperatures. The open circuit voltage became nearly independent of temperature below a transition temperature $T_t$ which depends upon the sunlight intensity. No such transition was observed with the p-n cells. An analysis of the voltage−current curves produced by the n-p cells suggests that the current−voltage relation is dominated by a mechanism other than the recombination current at low temperatures. Further work may enable solar manufacturers to limit low temperature open circuit voltage. (auth)

## Fluid Physics

*Refer also to abstracts 2079 and 2083.*

**2086** CONSIDERATION OF THE DESIGN OF MHD GENERATORS. Yanagisawa, Hifumi (Meidensha Electric Mfg. Co., Ltd., Japan). Meidensha Jiho, No. 65, 23-6(Dec. 1965). (In Japanese).

A tentative analytical formulation for the thermodynamic characteristics in the normal MHD generating ducts is first presented; the ducts of various types such as constant cross-section, constant-velocity, constant-Mach-number, constant-temperature, constant-pressure, and constant-density, are compared under the same load factor. Next, the optimum design for the type of duct and the load factor is discussed, by the numerical calculation, against the geometrical size of the ducts. It is proved that the constant-velocity or the constant-Mach-number type is most favorable at the load factor 0.7 and 0.8 in the case of the combustion gas or the inert gas, respectively. Based on the above analysis, it is proved that the total efficiency of the power plant with a topper of MHD generator cannot exceed 50% without the preheating of the operating air or the addition of oxygen. The maximum total efficiency of the plant is about 60% without the limit of the geometrical size, but, for the practical purpose, the total efficiency of the plant is about 50%. In the estimation of the generating cost, the equipment for the additional oxygen to the operating air cannot be neglected. (NSA of Japan)

**2087** SELF-SIMILAR MOTION IN MAGNETOGASDYNAMICS WITH VARIABLE CONDUCTIVITY. Kiselev, M. I. Teplofiz. Vysok. Temp., 4: 452-3(May-June 1966). (In Russian).

In real processes magnetic conductivity and, consequently, "magnetic viscosity" vary together with the thermodynamic parameters of a medium. It is shown that in many cases it is possible to find self-similar motion in a medium that has variable conductivity. A system of equations for symmetrical flow are presented and it is assumed that magnetic viscosity depends on pressure, density, and the magnetic field. Under certain assumptions, the system of equations has self-similar solutions for motion in a conducting medium in a strong field. The limitations of the approach are given, as well as the condition of current distribution in an unperturbed medium for self-similar motion to exist. (JPRS)

**2088** EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON THE HEAT EXCHANGE IN A LAMINAR FLUID FLOW IN A PLANE CHANNEL. Genin, L. G.; Podshibyakin, A. K. (Moscow Inst. of Power Engineering). Teplofiz. Vysok. Temp., 4: 369-74(May-June 1966). (In Russian).

Heat exchange in a conducting incompressible laminar flow in a flat channel in the presence of transverse electric and magnetic fields was studied. (tr-auth)

**2089** SWIRLING, RADIAL FREE JET IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD. Riley, Norman (Univ. of East Anglia, Norwich, Eng.). Z. Angew. Math. Phys., 17: 639-42(Sept. 25, 1966).

A theoretical discussion is presented on the swirling axisym-

metric radial jet flow of a conducting fluid in the presence of an axial magnetic field. The boundary layer equations for the flow are briefly discussed. (M.O.W.)

**2090** MHD ACCELERATOR PERFORMANCE FOR SPECIFIED INTERACTION PARAMETER. Marston, Charles H. (General Electric Co., Philadelphia). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 4: 2078-9(Nov. 1966).

Analytic solutions for MHD channel flow are useful tools for preliminary performance studies because they permit rapid computations for a wide range of parameters. The full range of possible exit states attainable with a given accelerator, having a specified magnetic interaction parameter established by physical limitations, is considered. The range of performance available for interaction parameters of 0.4, 1, and 4 is shown, assuming a perfect gas with $M_a = 1$. (W.D.M.)

**2091** VARIATIONAL PRINCIPLE IN RELATIVISTIC MAGNETOHYDRODYNAMICS. Tam, Kwok-Kee (Univ. of Windsor, Ont.). Can. J. Phys., 44: 2403-9(Oct. 1966).

The system of equations governing the behavior of an ideal, relativistic charged, fluid are derived by a variational principle, through the introduction of a generalized Clebsch transform. Some simple applications are considered. (auth)

**2092** MAGNETOHYDRODYNAMIC FLOWS IN CLOSED REGIONS WITH COMPLETE SYMMETRY ABOUT AN AXIS. Eraslan, Arsev Huesnue. Raleigh, N. C., North Carolina State of the Univ. of North Carolina, 1965. 176p.

Thesis.

A formal perturbational technique was developed to obtain solutions for magnetohydrodynamic flow problems in closed regions with symmetric properties of flow and boundary conditions about an axis. The system of highly nonlinear partial differential equations governing the problems of this class was found to reduce to systems of simultaneous linear partial differential equations, thus creating a possibility of obtaining solutions by classical mathematical methods. The technique used was based on a well-known power series type of perturbational expansion in terms of a small parameter, which in the limit was assumed to become the solution of the original system. The proofs for the existence and the uniqueness of the solution were omitted because of the high complexity of the successive perturbational equations and due to the inadequacy of the theories on nonlinear partial differential equations. The general technique was applied to the magnetohydrodynamic flow in a toroid under the influence of a uniform applied magnetic field along the direction of the main axis of the toroid. It was found that the secondary flow caused by the centrifugal body force on the fluid element due to the curvature created induced electromagnetic components and a pressure variation along the radial direction. The solutions were carried out to include completely the second perturbational equations and the electromagnetic and flow fields were discussed for different values of characteristic parameters appearing in the solution. The type of mathematical functions to be expected for higher order approximations were discussed and the limitations on the characteristic parameters for the convergence of the solutions were investigated for the particular problem. (Dissertation Abstr.)

## Geophysics

*Refer also to abstracts 1328, 1558, 1976, 1990, 1995, and 1996.*

**2093** (AD-640323) CORPUSCULAR RADIATION ENVIRONMENT OF A LOW-ALTITUDE, POLAR-ORBITING EARTH SATELLITE: A BRIEF SUMMARY. Air Force Surveys in Geophysics, No. 185. Smalley, V. G.; Smart, D. F.; Filz, R. C. (Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.). July 27, 1966. 37p. (AFCRL-66-540). CFSTI $2.00 cy, $0.50 mn.

The most recent determinations of particulate fluxes, flux rates, and energies for geomagnetically trapped radiation, galactic cosmic, and solar cosmic rays are summarized. (auth)

**2094** (AD-641481) TRANSMISSIVITY OF THE ATMOSPHERE FOR THERMAL RADIATION FROM NUCLEAR WEAPONS. Gibbons, M. G. (Naval Radiological Defense Lab., San Francisco, Calif.). Aug. 12, 1966. 39p. (USNRDL-TR-1060). CFSTI $2.00 cy, $0.50 mn.

The transmissivity of the atmosphere is estimated for thermal radiation from a nuclear weapon of any given yield and height of burst under various atmospheric conditions. Situations in which the effective source height (for thermal radiation) is less than one-quarter mile, the atmosphere is unclouded and the surface of the earth (or its covering) is of low albedo are considered first. The transmissivity for these situations is given in terms of a formula derived from earlier experiments of the author. Situations in which the effective source height (for thermal radiation) is equal to or greater than one-quarter mile are then considered, and basic transmissivity values are given in terms of effective fireball height and zenith angle for the case of an unclouded atmosphere, a visibility of about 12 miles and a low surface albedo. Factors are then given for modifying the basic transmissivity values to apply to other situations, such as ones with cloud cover or haze, and for taking into account high surface albedo. The factors for taking account of a cloud layer above the fireball and/or a high surface albedo are found to apply also to situations in which the effective fireball height is less than one-quarter mile. (auth)

**2095** SOME RESULTS OF ELECTRON CONTENT MEASUREMENTS AT DELHI FROM FARADAY FADING OF S-66 TRANSMISSIONS. Tyagi, Tuhi Ram; Somayajulu, Y. V. (National Physical Lab., New Delhi). Radio Sci., 1: 1125-30(Oct. 1966).

Results are presented of analysis of the total electron content ($I_s$) measurements made from the recordings of Faraday rotation at Delhi of the 20- and 40-Mc transmissions of the satellite Explorer 22 (S-66) for the period October 1964 through June 1965, the period of low solar activity. The results show that the diurnal maximum is reached around 1300 to 1400 IST, while at night the electron content falls to low values, decreasing slowly with time until 0600 when it starts to increase. The variations in $I_s$ closely follow the $f_0F2$ variations. The ratio $I_{smax}/I_{smin}$ increases from 7 for October–December 1964 through 10 for January–March 1965 to about 25 for April–June 1965. It is interesting to note that electron content values are more or less independent of solar activity until the 10-cm solar flux exceeds about 80 units. Above 80 units, there is a positive correlation. The study of dependence of $I_s$ on magnetic activity shows that there is positive correlation during daytime, while nighttime values do not show any dependence on magnetic activity. In addition, the electron content seems to have a correlation with solar zenith angle. General features of the thickness parameter $\tau$ and the ratio of total to subpeak electron content $I_s/I_b$ are also given. The variations of $\tau$ are correlated with both solar flux and $h_mF2$ variations. Preliminary examination of occurrence of scintillations is also given. (auth)

**2096** GEOGRAPHICAL DISTRIBUTION OF TOTAL ELECTRON CONTENT DEPENDENCE ON GEOMAGNETIC ACTIVITY. Bertin, F.; Papet-Lepine, J.; Vassy, E. (Univ., Paris). Radio Sci., 1: 1131-4(Oct. 1966).

A comparison study was made of the distribution of the total electron content over Europe, in terms of the geomagnetic activity. When geomagnetic activity is low, the geographical distribution of the total electron content shows some irregularities which could be linked to the observation of scintillations. When geomagnetic activity is high, the total electron content is increased but the geographical distribution is much more regular. In such a case, a lack of scintillations is noticed in southwestern Europe. (auth)

**2097** LATITUDINAL AND DIURNAL VARIATIONS OF THE IONOSPHERIC ELECTRON CONTENT NEAR THE AURORAL ZONE IN WINTER. Liszka, Ludwik (Kiruna Geophysical Observatory, Sweden). Radio Sci., 1: 1135-7(Oct. 1966).

The analysis of 3-months' observations of Faraday rotation observed on S-66 transmissions made at the Kiruna Geophysical Observatory ($\varphi = 67.8°N$, $\lambda = 20.3°E$) is presented. The ionospheric electron content along the subionospheric path of the satellite was computed for almost 400 transits. Effective slab thicknesses were calculated using critical frequency values from six Scandinavian stations, covering an interval of 10° of latitude. Latitudinal and diurnal variations of the ionospheric electron content and the effective thickness were studied. The most striking feature of the latitudinal variation of the total electron content was a distinct minimum at the southern boundary of the auroral zone during winter nighttime. This minimum coincides with the "trough" observed by topside sounding satellites. (auth)

**2098** MEASUREMENT OF THE TOTAL ELECTRON CONTENT WITH THE DIFFERENTIAL FARADAY EFFECT USING THE SATELLITE EXPLORER 22. Muenther, Christian (Ionosphaeren-Institut, Breisach, Ger.). Radio Sci., 1: 1141-5(Oct. 1966).

The signals of the American satellite Explorer 22 on 20, 40, and 41 Mc were received and their amplitudes recorded. The records show the Faraday effect when a fixed linearly polarized antenna is used. Using the Faraday effect, the total electron content can be computed, the total number of rotations being determined by comparing records of 40 and 41 Mc. These considerations are based upon the period January–April 1965. Total electron content decreasing to the north prevails. In addition, a comparison of the Faraday effect on 20 and 40 Mc was performed. At small zenithal distances the Faraday periods on both frequencies (reduced to the same frequency) become equal; at larger distances typical deviations are observed. (auth)

**2099** VARIATION IN IONOSPHERIC ELECTRON CONTENT MEASURED BY RADIO WAVES FROM SYNCOM 3. Nakata, Yoshiaki (Radio Research Labs., Tokyo). Radio Sci., 1: 1145-8(Oct, 1966).

Measurements of the Faraday rotation of a 136.98-Mc signal radiated from the geostationary satellite Syncom 3 is used to determine the time variation in the total electron content in the ionosphere. Good agreement of the time variation between the Faraday rotation and the square of $f_0F2$ is found, and the slope of the line of this relation is determined by the distribution of electron density at a particular height. Absolute values of total electron content are determined from the intercept on the ordinate intersected by this line. Good agreement is maintained not only on the quiet day, but also on the disturbed day. (auth)

**2100** MIDDLE-LATITUDE IONOSPHERIC TOTAL ELECTRON CONTENT: SUMMER 1965. Klobuchar, J. A.; Whitney, H. E. (Air Force Cambridge Research Labs., Bedford, Mass.). Radio Sci., 1: 1149-54(Oct. 1966).

The total electron content of the ionosphere was measured continuously from a northern mid-latitude station during the summer of 1965 by monitoring the polarization twist of vhf radio signals from the Early Bird synchronous satellite. The ambiguity in the total amount of polarization twist of the Early Bird signal was resolved by measuring the total polarization twist of a lunar reflected radio wave at a time when the moon coincided in direction with Early Bird. Large day-to-day differences in electron content were seen. The late afternoon maximum value of electron content was not well related to magnetic activity. Many small, irregular changes in electron content were observed. Diurnal values of electron content were much lower than those observed during 1961. Observations of polarization twist of vhf radio waves from synchronous satellites provide a simple, accurate means of measuring diurnal, seasonal, and anomalous changes in ionospheric total electron content. (auth)

**2101** IONOSPHERIC MEASUREMENTS BY MEANS OF THE EARLY BIRD GEOSTATIONARY SATELLITE. Checcacci, P. F. (CNR, Florence). Radio Sci., 1: 1154-8(Oct. 1966).

The vhf emission of the Early Bird geostationary satellite during the period June 23 to July 9, 1965, was used for ionospheric measurements at Florence, Italy (43°48'N, 11°13'E). Electron content daily variation curves obtained from Faraday rotation measurements show a maximum-to-minimum ratio of about 5. The equivalent slab thickness ranges from 140 to 310 km. The scintillation occurrence shows maxima at night and at noon. (auth)

**2102** BRIEF REVIEW OF SCINTILLATION STUDIES. Briggs, B. H. (Univ. of Adelaide). Radio Sci., 1: 1163-7(Oct. 1966).

A brief review is given of certain selected aspects of radio star and satellite scintillations. The topics discussed include the theory of wave propagation through random media, the bandwidth of scintillations, secondary effects which may reduce scintillations, and interplanetary scintillations. The review ends with a discussion of some outstanding problems in this field. (auth)

**2103** ON THE TOPSIDE IONOSPHERE OVER THE AMERICAN CONTINENTS. Chan, K. L. (Ames Research Center, Moffett Field, Calif.). Radio Sci., 1: 1158-62(Oct, 1966).

Preliminary results of an extensive investigation of the topside ionosphere over the North and South American continents are presented. The required data are obtained through the reduction and analysis of a large number of Alouette I topside ionograms. Illustrative examples of typical latitudinal variations (from 80°N to 80°S geographic latitudes or 90°N to 60°S dip latitudes) of electron density (N) and corresponding scale height ($H_v$) are presented. The characteristic features of equatorial, mid-latitude and polar ionospheres are described. Assuming the topside ionosphere is in a state of diffusive equilibrium above 500 km, the scale height of electron distribution along magnetic field lines ($H_s$) is calculated. The physical significance and interpretation of the computed scale height, ($H_s$), curves are discussed. (auth)

**2104** PARAMETERS OF A CLOUD-LIKE DISTRIBUTION OF ELECTRONS IN THE IONOSPHERE. Hughes, Leroy R. (Smyth Research Associates, San Diego, Calif.). Radio Sci., 1: 1171-5(Oct, 1966).

Wide bandwidth differential phase measurements were taken on the 162- and 324-Mc emissions of Anna 1B and 6303Bc satellites from Point Buchon, Calif. and College, Alaska. The measurements are analyzed to determine parameters describing fine scale electron distribution in contrast to smooth ionosphere parameters. Electron content variations show a cloud-like structure with apparent scale sizes less than 20 m in both day and night ionospheres. (auth)

**2105** HIGH-LATITUDE RADIO STAR SCINTILLATION MEASUREMENTS AT 68 Mc/s MADE WITH A PHASE-SWEEP INTERFEROMETER SYSTEM. Lansinger, John M. (Boeing Scientific Research Labs., Seattle). Radio Sci., 1: 1176-9 (Oct. 1966).

A quantitative evaluation and comparison are made of independent 68 Mc angular and amplitude scintillation data received at the College, Alaska, experimental station. A phase-sweep interferometer system is employed and the outputs are digitized for subsequent analyses. A correlation analysis is made between ionospheric absorption, magnetic variation, and the angular and amplitude scintillation data. Some results are presented which show an association between short-term absorption events and the enhancement of scintillation activity. Power spectral analysis and cross-correlation analysis are made of the experimental data. Given theoretical ionization models, the computed ground diffraction patterns are compared with experimental data. The majority of the observations are consistent with an ionospheric model comprised of kilometer-scale electron density gradients in combination with random scatterers. (auth)

**2106** SCINTILLATION OF A RADIO STAR AT A SUBAURORAL LATITUDE. Aarons, Jules; Allen, Richard S. (Air Force Cambridge Research Labs., Bedford, Mass.). Radio Sci., 1: 1180-6(Oct. 1966).

Scintillations of the radio source Cassiopeia A observed at 113 Mc during the period October 1961 through July 1964 were scaled to determine a semi-quantitative index of the scintillation of source power. For fixed values of local magnetic activity mean diurnal variations were established which peaked about two hours before solar and magnetic midnight. Mean sidereal variation peaked at lower transit; this effect, attributed primarily to latitude, is compared to satellite scintillations. Both diurnal and sidereal variations showed an increase of mean scintillation activity with increase of magnetic index. Detailed examination of low magnetic index periods showed that daytime scintillations were slightly higher on the western side (towards the magnetic pole), while nighttime scintillations showed symmetry. However, with increasing magnetic activity, scintillation indices are considerably higher at night in the west while daytime scintillations are skewed to the east. A comparison of these observations with Penndorf's model of traveling and permanent maxima of spread F is attempted. The general features of the diurnal–latitude variation of the radio star scintillation index is compared to the diurnal and latitude variation of spread F (topside and bottomside). While there is a general correlation, differences between scintillations and spread F noted in topside sounders are considerable. (auth)

**2107** SEASONAL VARIATIONS IN OCCURRENCE OF SCINTILLATION. Munro, George H. (Univ. of Sydney). Radio Sci., 1: 1186-8(Oct. 1966).

Observations of scintillation on signals radiated on a frequency of 20.005 Mc from a series of satellites are used to derive diurnal variations in the appearance of scintillation. Marked seasonal changes in daytime scintillation are apparent, but it is shown that summarizing for the four conventional seasons may mask some of the more significant changes. (auth)

**2108** MULTIFREQUENCY OBSERVATIONS OF SUDDEN COSMIC NOISE ABSORPTION AND X-RAY FLARES. Mitra, A. P.; Subrahmaniyam, C. V.; Jain, V. C. (National Physical Lab., New Delhi). Radio Sci., 1: 1188-95(Oct. 1966).

Results are reported of (a) a study of sudden cosmic noise absorption (SCNA) observations made with a multifrequency riometer system operating at Delhi, and (b) a comparative study of SCNA's and satellite measurements of x-ray flux. Multifrequency riometer observations of SCNA's recorded at Delhi show that while for many SCNA's the peak absorption remains at the preflare level, for some it comes down appreciably to heights between 60 to 70 km. Examination of the nature of decay of the SCNA's shows that the quantity $\alpha(N + N_n)$ has values of (20 to 60) $\times 10^{-4}$sec$^{-1}$ near the peak of the flare, decreasing asymptotically to a constant value of $3 \times 10^{-4}$sec$^{-1}$ at the end of the flare. Comparison of the times of maximum of SCNA's with those of x-ray flux obtained from observations made with the Vela, SR-1, and Aeriel-1 satellites gave an average relaxation time of 3 to 4 min, which is of the same order as that obtained with $H_\alpha$ time curves. For one of the SCNA events, that of October 20, 1963, for which information is available on solar x-ray flux from observations of the Vela satellite, computations of absorption profiles were made on the basis of different models of loss coefficient, and compared with the observed ab-

sorption values. It is suggested that SCNA events for which the frequency ratio is lowered appreciably below the preflare value are an indicator of "nonthermal" type of x-ray bursts. (auth)

**2109** INFLUENCE OF SOLAR PROTONS ON HIGH-LATITUDE IONOSPHERIC DISTURBANCE. Elkins, Terence J. (Wentworth Inst., Boston). Contract AF19(628)-3282. Radio Sci., 1: 1195-1200(Oct. 1966).

High-latitude ionospheric absorption is shown to exhibit a magnetic, rather than local, time dependence. The spatial and temporal variations of absorption are compared to the same variations of impact zones for solar protons in the energy range 50 MeV to 1.0 BeV, and the agreement is shown to be good. Similar agreement is found when various other ionospheric disturbance parameters are considered. The conclusion is tentatively reached that a more or less continuous flux of solar protons is entering the earth's atmosphere, which if valid, would have important consequences in the study of the energy balance of the ionosphere as well as that of the sun itself. (auth)

**2110** RAY-TRACING STUDY OF HF DUCTING PROPAGATION WITH SATELLITES. Wong, Ming S. (Air Force Cambridge Research Labs., Bedford, Mass.). Radio Sci., 1: 1214-22(Oct. 1966).

Ray patterns, showing the spatial distribution of rays emitted from a transmitter and then progressively refracted in the medium, are presented for frequencies from 13.6 to 40 Mc, and for variations of the ionosphere in one to three dimensions. The patterns portray the elevated radio ducts, with down-to-earth contacts, responsible for long-distance and round-the-world propagation. It is shown that constancy of Doppler frequency shift, in signal reception from an antipodal satellite pass, is a condition enabling the signal to persist some minutes, and that this constancy implies propagation off the great-circle path. (auth)

**2111** SATELLITE ORBIS EXPERIMENT. Basu, S.; Sarkar, S. (Univ. of Calcutta). Radio Sci., 1: 1223-4(Oct. 1966).

Signals transmitted by satellite ORBIS at 10.004 Mc were received at Haringhata Field Station (geomagnetic lat. 12°15'N, geomagnetic long. 32°W). Long-distance propagation paths could be established between the station and the satellite in some passes, while a few overhead passes could not be received. Absence of signals from a few overhead passes is explained in terms of blanketing-type sporadic E. It is concluded that long-distance propagation paths may be sustained either by hop modes in the presence of irregularities in the ionosphere or by ionospheric ducting. (auth)

**2112** ROCKET MEASUREMENT OF PROTON ENERGY SPECTRA AND PITCH ANGLE DISTRIBUTION IN THE AURORAL ZONE. Soeraas, F.; Trumpy, B. (Univ. of Bergen). J. Atmos. Terrest. Phys., 28: 1081-91(Nov. 1966).

A rocket experiment to study protons associated with auroral radio absorption is described. Protons in the energy range greater than 100 keV were recorded. During the flight the intensity changed by a factor of three. The integral proton energy spectrum could approximately be represented by exp (–E/150) keV. The pitch angle distribution had a maximum at 90°. The measured proton flux was insufficient to account for the observed radio absorption. (auth)

**2113** INTERPRETATION OF IONOSPHERIC DRIFT MEASUREMENTS. MacDougall, J. W. (McGill Univ., Montreal). J. Atmos. Terrest. Phys., 28: 1093-1109(Nov. 1966).

An investigation of the variability of drift velocities as measured by the method of radio fading on spaced receivers showed that drift velocities for the F region are a rapidly varying function of time with significant velocity changes taking place in a few minutes. The fluctuations of velocity can be explained by the movement of the point of reflection over an ionospheric surface which is being tilted by the passage of traveling ionospheric disturbances. (auth)

**2114** SOME REMARKS ON PAPERS CONCERNING THE GEOMAGNETIC ANOMALY OF THE F2 LAYER. Burkard, O. M. (Univ. of Graz). J. Atmos. Terrest. Phys., 28: 1129-30 (Nov. 1966).

The author (Burkard) drew attention to the geomagnetic anomaly as early as 1942. Subsequent papers which describe this, and allied, phenomena are briefly discussed. (J.H.M.)

**2115** GEOMAGNETIC AND IONOSPHERIC EFFECTS OF MAGNETOSPHERIC MOTIONS. Poeverlein, H. (Air Force Cambridge Research Labs., Bedford, Mass.). J. Atmos. Terrest. Phys., 28: 1111-23(Nov. 1966).

A section of the magnetosphere is subject to a varying pressure of the solar plasma wind during its rotation with the Earth and in the course of disturbances, in which the plasma wind intensity is increased. The expected motions of the magnetospheric plasma are discussed in terms of hydromagnetic-wave theory. Crude estimates indicate the importance of the motions for variations of the geomagnetic field and of the ionospheric plasma density. (auth)

**2116** INFLUENCE OF THE EARTH'S ROTATION UPON THE INTERACTION OF THE SOLAR WIND WITH THE MAGNETOSPHERE. Hones, Edward W. Jr. (Univ. of Iowa, Iowa City). J. Geophys. Res., 71: 5186-90 (Nov. 1, 1966).

To study the influence of the earth's rotation upon solar wind interactions with the magnetosphere, an experiment was conducted with rotating objects in water in a situation similar to the solar wind–magnetosphere system. The results lend plausibility to a previous suggestion that the circulatory convection in the magnetosphere derives its basic direction and pattern from the earth's rotation but is largely powered by plasma diverted from the passing solar wind. (J.H.M.)

**2117** RECONSIDERATION OF ELECTRON ATTACHMENT RATE MEASUREMENTS IN THE LOWER IONOSPHERE. Hodges, R. R. Jr. (Southwest Center for Advanced Studies, Dallas). J. Geophys. Res., 71: 5191-2(Nov. 1, 1966).

Previous electron attachment rate measurements in the lower ionosphere indicate an altitude dependence suggestive of a two-body attachment process. As the resulting rate coefficient does not correspond to any expected atmospheric process, and as there is general agreement that a three-body attachment process should dominate in the lower ionosphere, a re-examination of the experimental data and their interpretation was undertaken. The attachment rate and the square of molecular oxygen concentration as functions of altitude and the three-body attachment vs. altitude are plotted. (J.H.M.)

**2118** RED SHIFT OF AURORAL HYDROGEN PROFILES. Eather, R. H. (Rice Univ., Houston, Tex.). J. Geophys. Res., 71: 5027-32(Nov. 1, 1966).

The injection pitch-angle distribution of auroral protons required to explain the observed red shift of magnetic zenith hydrogen line profiles is one that is essentially isotropic up to about 60 or 70° and is then peaked (at least for low-energy protons) at higher pitch angles. When this result is considered in light of rocket and satellite measurements of pitch-angle distributions of auroral protons, it implies that there are appreciable fluxes of low-energy protons (below about 10 keV) with a pitch-angle distribution peaked above about 70° or, alternatively, that proton trajectories are perturbed in the ionosphere below about 300 km by some mechanism that favors increased pitch angles. (auth)

**2119** CHARACTERISTICS OF PRECIPITATED ELECTRONS INFERRED FROM IONOSPHERIC FORWARD SCATTER. Bailey, D. K. (Inst. for Telecommunication Sciences and Aeronomy, Boulder, Colo.); Pomerantz, M. A.; Sullivan, K. W.; Taieb, C. C. J. Geophys. Res., 71: 5179-82(Nov. 1, 1966).

A summary is presented of some of the characteristics of 72 relativistic electron precipitation events as observed during a 21-month period, including most of 1964 and 1965. Certain generalized conclusions concerning the spectra of electrons that are precipitated in and near the auroral zones, both during daytime and at night, are presented. (J.H.M.)

**2120** INCOHERENT BACKSCATTER OBSERVATIONS OF SPORADIC E. LaLonde, L. M. (Cornell Univ., Ithaca, N. Y.). J. Geophys. Res., 71: 5059-65(Nov. 1, 1966).

Measurements of the characteristics of sporadic E over Arecibo, Puerto Rico, by backscatter radar and ionosonde are presented. A comparison of backscatter to ionosonde data indicates that observed layer thicknesses vary between 35 and 850 meters. Horizontal structure in one dimension has been observed to lie within limits of 1 to 10 km with reasonable assumptions of cloud velocity. Vertical velocity of the lower layers (90 to 110 km) is of the order of 1 km per hour downward, while that of a thicker, higher layer is observed to be about 1 order of magnitude greater. $E_s$ is observed most frequently during summer, generally forming at sunset when the layers appear to be uncovered by the diminishing ambient electron number density of the E region. The observations of what appear to be sporadic D layers are also reported. (auth)

**2121** GROUND-BASED STUDIES OF THE F REGION IN THE VICINITY OF THE MIDLATITUDE TROUGH. Stanley, Glenn M. (Univ. of Alaska, College). J. Geophys. Res., 71: 5067-75 (Nov. 1, 1966).

It is shown that the 'oblique' echo observed on ionograms taken at auroral and subauroral latitudes is present during most winter nights. The morphology of the oblique echo, its cause, and some consequences of its existence are discussed. In addition, it is shown that the maximum electron number density of the regular nighttime F region in the vicinity of the mid-latitude trough is considerably less than previously thought. The suggestion is made

that the residual ionization in the nighttime F region at mid-latitudes is a result of diffusion from the magnetic conjugate area Observations of $f_0F2$ during winter nights seem to substantiate diffusion theories for maintenance of the nighttime F region. (auth)

**2122** FAST NEUTRON LATITUDE VARIATIONS IN THE ATMOSPHERE AT SOLAR MINIMUM. Holt, S. S.; Mendell, R. B.; Korff, S. A. (New York Univ., N. Y.). J. Geophys. Res., 71: 5109-16(Nov. 1, 1966).

The fast-neutron flux in the atmosphere was measured during solar minimum. Data from ground level to about 4 g/cm$^2$ were obtained in a series of seven high-altitude balloon flights. The flights were conducted between September 1964 and August 1965 at four locations between $\lambda = 8°$N and $\lambda = 69°$N, conventional geomagnetic latitude. The detector, a phoswich-type scintillator, was sensitive to neutrons in the range 1 to 10 MeV. A seven-channel pulse-height analyzer permitted the evaluation of the energy spectrum in this range. The neutron flux at the transition maximum increased from $0.17 \pm 0.02$ cm$^{-2}$ sec$^{-1}$ at $\lambda = 8°$N to $1.9 \pm 0.1$ cm$^{-2}$ sec$^{-1}$ at $\lambda = 69°$N. Neutron leakage from the top of the atmosphere was estimated by extrapolation. The magnitudes of the leakage fluxes, as well as the pole-to-equator ratio of 16, were in substantial agreement with the results of the diffusion calculation of Lingenfelter. The best fit to an inverse power law of the differential neutron energy spectrum was found to be independent of latitude within the limits of our experimental precision. Averaged over all flights, the best fit was for a special index of $n = 1.05 \pm .15$. This spectrum is harder than that calculated by Lingenfelter. Differences in the shapes of the neutron profiles of this experiment and of the calculation are consistent with the difference in spectrum. (auth)

**2123** ADIABATIC MOTION OF OUTER-ZONE PARTICLES IN A MODEL OF THE GEOELECTRIC AND GEOMAGNETIC FIELDS. Taylor, Harold E. (Univ. of Iowa, Iowa City). J. Geophys. Res., 71: 5135-47(Nov. 1, 1966).

Calculations of charged particle motions are carried out in a model of the earth's magnetosphere that includes both a magnetic field and an electric field. The magnetic field is an analytical approximation of the real field, based on extensive satellite measurements, while the electric field is deduced in the ionosphere from an ionospheric current system and mapped throughout the magnetosphere by assuming that the magnetic field lines are equipotentials. Using this model, the motions of charged particles are calculated by assuming that the first two adiabatic invariants, $\mu$ and J, and the total energy K are all conserved. Particle fluxes are then calculated by invoking Liouville's theorem. The computations are done numerically on the University of Iowa IBM 7044 computer, and the results obtained for outer-zone electrons are found to be in agreement with experimental measurements of the Injun 3 satellite. Predictions of as yet unmeasured quantities are presented for comparison with future experiments. (auth)

**2124** THEORY OF POLAR SUBSTORMS. Atkinson, G. (Univ. of British Columbia, Vancouver). J. Geophys. Res., 71: 5157-64(Nov. 1, 1966).

It is suggested that an important feature of magnetospheric processes is the interchange of field lines between the closed region of the magnetosphere and the open tail. It is demonstrated that if recombination occurs impulsively at the neutral sheet, the resulting flow of flux tubes can explain many of the features of auroral breakup and geomagnetic bays. (auth)

**2125** PLASMAS IN SPACE. Levine, Morton A. (Air Force Cambridge Research Labs., Mass.). IEEE (Inst. Elec. Electron. Eng.), Spectrum, 3: 43-7(Nov. 1966).

A review is presented of new findings and speculations on solar dynamics with emphasis on the interactions of the solar wind with the magnetosphere of the earth. (J.H.M.)

**2126** TRANSVERSE MAGNETIC DISTURBANCES AT 1100 KILOMETERS IN THE AURORAL REGION. Zmuda, A. J.; Martin, J. H.; Heuring, F. T. (Johns Hopkins Univ., Silver Spring, Md.). J. Geophys. Res., 71: 5033-45(Nov. 1, 1966).

Transverse magnetic disturbances are regularly observed at 1100-km altitude in the auroral region with the magnetically oriented satellite 1963-38C. For the dayside period 1000 to 1400 LT the lower-latitude boundary of the disturbance region has an average invariant latitude $\Lambda_b$ of 76° during magnetic quiet ($K_p < 4o$) and shifts southward to $\Lambda_b = 68°$ during periods of magnetic activity ($K_p \geq 4o$). For 2300 to 0100 LT, this latitude is 67° when $K_p < 4o$ and is 63° when $K_p \geq 4o$. The magnetic amplitudes range from about 30 $\gamma$ (the minimum here detectable) to 380 $\gamma$, or about 1% of the local geomagnetic field. Such variations are absent between $\Lambda = 31°$ (the minimum sampled) and the $\Lambda_b$ appropriate to the local time and $K_p$. The quiet-time location and diurnal variation of the magnetic disturbance region correspond to those for the auroral oval and the trapping cutoff electrons ≥40 keV; all three phenomena have a nightside position comparable to the trapping cutoff for electrons ≥280 keV and ≥1.2 MeV, whose dayside displacement is also toward higher latitudes but with a small diurnal shift, ≈2°. The location and diurnal variation of the region containing most of these geophysical properties are reflected in the surface values of magnetic intensity recorded at the Baker Lake ($\Lambda = 75°$) and Fort Churchill ($\Lambda = 70°$) observatories; around local noon the Baker Lake values exceed those for Fort Churchill, while the reverse is true at local midnight. (auth)

**2127** SIMULTANEOUS TRAPPED ELECTRON AND MAGNETIC TAIL FIELD OBSERVATIONS. Williams, Donald J.; Ness, Norman F. (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res., 71: 5117-28(Nov. 1, 1966).

Using data from the polar orbiting satellite 1963-38C, the behavior of the high-latitude energetic (≥280 keV) electron trapping boundary, $\Lambda_c$, at 1100 km is presented for the period March 15 through June 3, 1964. A sudden collapse of $\Lambda_c$ to lower latitudes during the onset of magnetic storms, as indicated by $K_p$ and $D_{st}$, is found to be a characteristic feature of the low-altitude trapped electron population. Details of this behavior are presented and discussed. In addition, during this time period, the NASA IMP 1 satellite sampled field characteristics in the geomagnetic tail. Correlated observations of the simultaneously observed behavior during magnetic disturbances of the 1100-km trapped electron population and of the field strength in the tail are presented. In three cases there is agreement and in one case disagreement with the latitude decreases that are predicted with an extended geomagnetic tail configuration. These results are considered to be direct evidence of the important influence exerted by the geomagnetic tail field in governing not only the quiet-time trapped particle distribution, but also the behavior of the trapped particle population during magnetic storms. (auth)

**2128** METHOD OF DISCHARGING A CLOUD. Moses, Harry; Martin, Ronald L. (to U. S. Atomic Energy Commission). U. S. Patent 3,284,686. Nov. 8, 1966.

A method of discharging a cloud is presented wherein a path of ionized air is established between the earth and a charge center of the cloud by transmitting a pulse of relativistic charged particles from a particle accelerator to the cloud charge center leaving in its wake the path of ionized air. (AEC)

## Low-Temperature Physics

*Refer also to abstract 2343.*

**2129** (IS-1453) ORDERING OF MAGNETIC IMPURITIES IN SUPERCONDUCTORS. Finnemore, D. K. (Ames Lab., Iowa State Univ. of Science and Tech.). Oct. 19, 1966. Contract W-7405-eng-42. 4p. (CONF-660821-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Low Temperature Calorimetry Conference, Helsinki, Finland.

The changes in the superconducting characteristics as the magnetic ions order are investigated. The thermal conductivity of La 0.8 at. % Gd was measured from 5° to 0.3°K for magnetic fields up to 20,000 Oe. Experimental results show that the normal state conductivity is nearly linear in temperature and to an accuracy of 2% the thermal conductivity is independent of magnetic field. It is tentatively concluded that the electrons are the major carriers of heat and that the mean free path is limited by non-magnetic impurity scattering. $K_s/K_n$ is plotted. Near $T_c$ the data do not lie below the pure metal values as predicted by the theory, and at low temperatures the superconducting conductivity drops more abruptly than the theoretical curve. (M.H.R.)

**2130** (UCRL-16450) THE HEAT CAPACITY OF SOLID $^4$He AT MOLAR VOLUMES BETWEEN 20.5 AND 21.1 cm$^3$/mole. Gardner, William Reavis (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1966. Contract W-7405-eng-48. 84p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Thesis.

The heat capacity of $^4$He was measured under constant-volume conditions from 0.32°K to the melting curve and at fourteen volumes ranging from 20.50 to 20.934 cm$^3$/mole. The measurements offer a significant increase in precision over other recently reported data and thus provide more definite answers to several outstanding questions. A linear term of 1.25 T millijoules/mole-°K was found in the heat capacity of the hcp phase, independent of volume and thermal history to within the precision of the measurements. Otherwise the hcp solid was found to be well-behaved and to have a Grüneisen constant of $3.2 \pm 0.1$ in this region. The thermal expansion coefficient was found to be definitely positive throughout the hcp phase and 90% of the bcc phase, although the possibility of a negative coefficient near the low-

temperature limit of the latter phase cannot be ruled out conclusively. The heat capacity of the bcc solid depends very strongly on density, exhibiting values of 8 to more than 30 for the Grüneisen $\gamma$. For this solid no discontinuity in $C_v$ is observed at the melting temperature, but the onset of melting is preceded by a narrow region of steeply increasing heat capacity which appears to be due to vacancy formation. (auth)

**2131** TUNNELLING IN A TWO-BAND MODEL SUPERCONDUCTOR. Radhakrishnan, V. (Tata Inst. of Fundamental Research, Bombay). Phys. Status Solidi, 18: 113-18(Nov. 1, 1966).

The Josephson and ordinary tunnelling currents are evaluated for two-band model superconductors. Numerical calculations of these currents are made for a niobium–tin junction, for which this model is applicable, and compared with experiments. (auth)

**2132** SUPERCONDUCTIVITY IN PSEUDOFERROELECTRICS. Appel, J. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Phys. Rev. Lett., 17: 1045-8 (Nov. 14, 1966).

Recently, superconductivity has been discovered in $SrTiO_3$ and in mixed titanates which can be denoted as pseudoferroelectrics, since their static dielectric constant $\epsilon$ is large and temperature-dependent, and since a low-energy optical mode has been observed which shifts with temperature as $[\epsilon(T)]^{\frac{1}{2}}$ in accordance with Cochran's theory of ferroelectricity. It is pointed out that inter-valley transitions must not necessarily be invoked to explain the occurrence of superconductivity in $SrTiO_3$ and similar polar substances. Instead, it is found that the contemporary theory of electron-phonon interactions in isotropic superconductors, based on the dynamic dielectric constant of the electron–phonon system for a polar substance, can account for the observed values of the transition temperature. (W.D.M.)

**2133** PROBLEMS IN APPLICATIONS OF SUPERCONDUCTIVITY. Alekseevskii, N. E. Izv. Akad. Nauk SSSR, Energ. Transp., No. 4, 3-11(July-Aug. 1966). (In Russian).

Use of superconductors promises to reduce substantially the dimensions of computers and the weight of electromagnets. The ideal superconductors are usually not too well suited for practical application but those possessing a long flat region in the critical current present a great interest. These materials include brittle intermetallic compounds, such as $Nb_3Sn$, and ductile transition metals. Wires, strips and cables may be prepared from these materials by drawing and rolling, followed by annealing. $Nb_3Sn$ wires may also be prepared by tin-plating niobium wires at about 700°C and insulating the system afterwards with a heat-resistant material to form a solenoid. Methods based on diffusion and the chemical decomposition of the niobium and tin halides are also used. Many of the units thus prepared are coated with copper which possesses a low heat conductivity. Such a nonsuperconducting metal stabilizes the operation of the superconducting system: when the superconductivity is disturbed, the current is allowed to pass through the copper which does not become overheated. (TTT)

**2134** PERSPECTIVES IN APPLICATIONS OF SUPERCONDUCTORS IN ELECTRIC MACHINES AND THE PROBLEM OF ISOLATING SUPERCONDUCTING SYSTEMS. Kazovskii, E. Ya. Izv. Akad. Nauk SSSR, Energ. Transp., No. 4, 12-25(July-Aug. 1966). (In Russian).

During the last decade many new superconducting alloys and compounds possessing a relatively high critical temperature have been developed. These so-called second-order superconductors include $V_3Ga$, $Nb_3Sn$, Nb–Ti and Nb–Zr. In spite of their potential usefulness, they are quite expensive and require large amounts of liquid helium for cooling; special steps must be taken to reduce the heat flow to the cryostat which occurs especially through the electrical leads. The plate and cylinder-type topological generator represents an interesting application of the principle. The magnet under the superconducting plate creates a local disturbance or "spot" in the superconducting system; by moving the magnet, it becomes possible to couple the magnetic flux with the superconducting circuit while keeping the expenditure of energy to a minimum. When the power of superconducting machines is increased, the elements do not become overheated and in most cases the efficiency increases because the losses do not increase. The maximum power is limited by the loss of the superconducting state and by the mechanical strength of the elements subjected to very high currents. Use of superconducting components opens up the possibility to build very large turbogenerators for aviation or other forms of transportation. (TTT)

**2135** UP TO DATE CONDITIONS AND PERSPECTIVES OF TECHNICAL USES OF SUPERCONDUCTIVITY. Sychev, V. V. Izv. Akad. Nauk SSSR, Energ. Transp., No. 4, 26-32(July-Aug. 1966). (In Russian).

The chief application of superconductors at present is in equipment for large-scale physical experimentation. Superconducting solenoids are used as strong magnetic-field sources for bubble chambers and for energy storage; they are found useful for creating magnetic traps in controlled-fusion research. Their application to the computer technology is especially promising. Thanks to their ideally diamagnetic character, superconductors achieve 100% screening of high-frequency systems. Superconducting magnetic systems may also be employed in space technology for shielding against cosmic radiation and for the creation of strong fields needed for plasma engines. Engineering design of these systems presents difficult problems arising from the requirements for high current and for nearly perfect cryostating. (TTT)

**2136** QUANTIZED VORTEX RINGS IN ROTATING HELIUM II. Schwarz, K. W.; Donnelly, R. J. (Univ. of Chicago). Phys. Rev. Lett., 17: 1088-90(Nov. 21, 1966).

Experiments are described on the propagation of quantized vortex rings in He II across an array of quantized vortex lines. Both scattering and capture of the charge carriers are observed. (auth)

**2137** THE CURRENT-CARRYING CAPACITY OF A HARD SUPERCONDUCTING WIRE IN ZERO EXTERNAL FIELD. Ullmaier, H. A.; Kernohan, R. H. (Oak Ridge National Lab., Tenn.). Phys. Status Solidi, 17: K233-5(Oct. 1, 1966).

An expression was derived for calculating the maximum transport current $I_c$ in zero external field. $I_c$ values were calculated for two Nb-25% Zr wires. Results were in good agreement with measured short sample quenching currents. (A.G.W.)

**2138** AC MEASUREMENTS ON HARD SUPERCONDUCTORS. Ullmaier, H. A. (Oak Ridge National Lab., Tenn.). Phys. Status Solidi, 17: 631-43(Oct. 1, 1966). (ORNL-P-2336).

Cylindrical samples of Pb–In, Nb–Zr, and Nb–Ta were exposed to a longitudinal, static magnetic field with a collinear alternating field, and the voltages produced in pickup coils wound around the samples were observed on an oscilloscope. The shape of the voltage–time curves can be adequately explained by considering a surface sheath able to carry a certain critical surface current and a bulk region where the pinning forces dominate the magnetic behavior. It is shown that an analysis of the voltage–time curves obtained yields values for the critical surface current and the bulk critical current density in good agreement with static measurements. While the bulk critical current density goes to zero when the external field reaches the upper critical field $H_{c2}$, the surface currents can be seen up to a field $H_{c3} > H_{c2}$. Values of the bulk critical current density obtained were then used to determine the pinning force per unit volume and the pinning force on a single vortex line, as a function of the vortex line density. (auth)

**2139** THE CURRENT-CARRYING CAPACITY OF A HARD SUPERCONDUCTING WIRE IN ZERO EXTERNAL FIELD. Koppe, H. (Univ., Kiel). Phys. Status Solidi, 17: K229-32 (Oct. 1, 1966).

A formula is derived for the maximum current that can be carried by a hard superconducting wire. Two assumptions are considered: that the maximum current is determined by the fact that the magnetic field on the surface of the wire is equal to $H_{c2}$ and that the wire carries everywhere exactly the critical current $J_c$. It is shown that, in reality, the maximum current is determined by a condition inside the wire. For very thick wires $I_M \approx 2\pi RH_{c2}$. (A.G.W.)

**2140** COEXISTENCE CURVE OF $^4$He NEAR THE CRITICAL POINT. Roach, Pat R.; Douglass, D. H. Jr. (Univ. of Chicago). Phys. Rev. Lett., 17: 1083-6(Nov. 21, 1966).

The coexistence curve of $^4$He was measured over the range 0.1 mdeg < $T_c$ to T < 250 mdeg. The data for $T_c$ to T < 100 mdeg fit an expression of the form $|\rho - \rho_c| \propto (P_c - P)^{\beta}P$, where $\rho$ is the density of either the liquid or the vapor, and P is the pressure; $\rho_c$ = 0.0701 ± 0.0006 g/cm$^3$, $P_c$ = 1705.0 ± 0.8 torr [$T_c$ = 5.1890 ± 0.0006°K], and $\beta_P$ = 0.355 ± 0.004. (auth)

**2141** ENERGY GAP AND CRITICAL CURRENT OF A SUPERCONDUCTING FILM WITH CURRENT FLOWING. Wu, Hang-sheng. Wu Li Hsueh Pao, 22: 765-9(July 1966). (In Chinese).

The energy gap of a superconducting film with current flowing is calculated, based on the theory reported earlier. The result is valid in the whole temperature range but only for small currents. The critical current of a superconducting film is also discussed for temperatures near $T_c$. It is pointed out that the nonlocal effect is important for thick films, but not for thin films. (auth)

**2142** DEPENDENCE OF THE ENERGY GAP OF A SUPERCONDUCTING FILM ON MAGNETIC FIELD. Wu, Hang-sheng; Jiang, Jian-xua; Ying, Run-jie. Wu Li Hsueh Pao, 22: 770-80 (July 1966). (In Chinese).

The energy gap of a superconducting film in a magnetic field was calculated. The result is valid in the whole temperature range

but only for small magnetic field satisfying the condition $[(e\hbar p_0/mc)(A/\pi k_B T_c)]^2 \ll 1$, where A is the vector potential and $\hbar p_0$ is the Fermi momentum. Results are compared with experimental data, and agreement is good. (auth)

**2143** SUPERCONDUCTIVITY OF HAFNIUM–RHODIUM ALLOYS. Wuehl, Helmut (Technische Hochschule, Karlsruhe, Ger.). Z. Phys., 197: 276-87(1966). (In German).

The transition temperatures $T_c$ of quenched Hf–Rh alloys are strongly increased in the hexagonal phase by Rh, similar to the homologous systems Ti–Rh and Zr–Rh. On the other hand a stabilization of the cubic high-temperature phase by Rh has not been possible. At higher amounts of Rh(>6 at. %) the intermetallic compound $Hf_2Rh$ with a $T_c$ of 1.98°K is formed. Moreover a transition temperature of 1.73°K is found which is probably due to the intermetallic compound HfRh. The results are interpreted with the help of x-ray diffraction and metallurgical techniques. (auth)

**2144** INVESTIGATION METHOD FOR STRONG SUPERCONDUCTORS. Chizhov, A. Kh. Izmeritel. Tekh., No. 8, 45-8(Aug. 1966). (In Russian).

Strong superconductors were studied using loop oscillographs capable of measuring current densities up to 20A. Critical current density $J_k$ as a function of the magnetic field intensity, critical temperature $T_k$, the ratio of resistance $R_{293°K}/R_{HP}$ and the transition from superconducting to normal state and return were measured on one oscillogram using subtraction of the drop in the intensity rather than the compensation method. (R.V.J.)

**2145** ELECTRICAL CONDUCTIVITY OF SOME CRYOGENIC FLUIDS. Willis, W. L. Cryogenics, 6: 279-84(Oct. 1966).

The possibility of generating hazardous electrostatic potentials in large liquid hydrogen flow systems led to a need for quantitative electrical conductivity information. The measurements of electrical conductivity were expanded to include liquefied nitrogen, deuterium, argon, carbon monoxide, and chlorotrifluoromethane as well as hydrogen. The fluids proved to be quite non-conductive and non-ohmic, with only a weak dependence between current density and applied voltage gradient. A difference in conductivity of about four orders of magnitude between hydrogen and deuterium is shown to be due to the presence of tritium as an impurity in the deuterium in a concentration of about 1 part in $10^9$. Observed conductivity in the other cryogens is attributed to cosmic ray induced charge carriers. (auth)

**2146** THE MOTION OF FLUX LINES IN TYPE II SUPERCONDUCTORS. Nozieres, P. (Cambridge Univ., Eng.); Vinen, W. F. Phil. Mag. (8), 14: 667-88(Oct. 1966).

The motion of a flux line in a clean superconductor of extreme type II ($\lambda \gg \xi$) at zero temperature is discussed in detail. It is shown that the vortex core is subject to a Magnus force identical to that found in liquid helium. The Magnus force balances the friction force exerted by the lattice on the core. The nature of this friction force is discussed, particularly in the light of a recent paper by Bardeen and Stephen. Different possible forms of the force are discussed and compared with experiment. (auth)

**2147** POTENTIOMETER FOR STUDYING THE LIQUID He II FILM. Keller, W. E.; Hammel, E. F. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. Lett., 17: 998-1001(Nov. 7, 1966). (LA-DC-8157).

A simple level-sensing device is described for probing the profile of the chemical potential along the flowing liquid He II film. Measurements with these probes indicate that dissipation in the flowing film may occur either at highly localized regions or over extended regions of the flow path, depending upon experimental variations. Also it is shown that changes in transfer rate occurring during a given flow process are accompanied by a redistribution of the sites producing dissipation. (auth)

**2148** HIGH-FIELD MAGNETIC, SEMICONDUCTOR, AND SUPERCONDUCTOR DEVICES. Freeman, A. J. (Massachusetts Inst. of Tech., Cambridge). IEEE (Inst. Elec. Electron. Eng.) Trans. Magnet., MAG-2: 164-5(Sept. 1966).

Some applications of magnetic field devices are discussed, including potential applications in plasma containment (e.g., magnetohydrodynamic power generators and nuclear fusion), nuclear particle accelerators (bubble chambers and beam handling), and focusing for ion propulsion systems. Some more-immediate practical applications comprise a large class based on the classical transverse galvanomagnetic effects (Hall, Nerst, Ettingshausen, Righi-Leduc). These include simple Hall devices for detection of magnetic fields and for measurement of flux density and field gradients, and for applications to linear and angular displacements, proximity sensors, and digital speed sensors. Other magnetic field effects under investigation are the magnetoresistance, Zeeman effect, first-order magnetic transitions, Faraday rotation, Kerr magneto-optical effect, cyclotron resonance, and electron paramagnetic resonance. Solid-state plasmas in semiconductors and semimetals being investigated at high magnetic fields are discussed. Nonreciprocal effects have been found indicating that isolators with low-noise characteristics are now possible at the lower microwave and radio frequencies. Several high magnetic field phenomena may be utilized as coherent or incoherent radiation sources. For example, in gaseous plasmas and in solid-state plasmas in modest fields, a plasma can be made to emit at the cyclotron frequency or its harmonics. The physics of superconductivity and its application are also considered. It is becoming evident that zero resistance is just one of the quantum properties of a superconductor which will be important to technology. Other somewhat more subtle effects result from the coherent wave motion of superconducting electrons. Thus a piece of a superconducting metal has a quantum or wave mechanical behavior and acts like a giant atom. These coherent electron waves, like those of light, can be reflected, refracted, and diffracted. Because their wavelength may be of the order of centimeters, it is possible to design and build macroscopic quantum mechanical systems. (BBB)

**2149** TUNNELING IN SUPERCONDUCTORS. Ivanchenko, Yu. M. (Academy of Sciences, Ukrainian SSR. Physical Technical Inst., Donetsk, USSR). Phys. Lett., 23: 289-90(Oct. 31, 1966).

The calculation for tunneling current determined from a self-consistent equation is presented. It is shown that when the electron energy in an extenal electric field is comparable with the energy gap of the spectrum of quasi-particle excitations, retarded effects are essential. (auth)

**2150** SUPPRESSION OF SURFACE SUPERCONDUCTIVITY BY COATING WITH A NORMAL METAL. Fischer, G.; Klein, R. (RCA Labs. Ltd., Zurich). Phys. Lett., 23: 311-12(Oct. 31, 1966)

The decrease of $H_{c3}$ was measured as function of the thickness of a copper layer deposited on top of lead. Care was taken to avoid oxidation of Pb before coating with Cu. The ratio $H_{c3}/H_{c2}$ decreases much more rapidly with Cu thickness than found previously. (auth)

**2151** THE PRODUCTION OF TEMPERATURES BELOW 1°K BY PUMPING ON LIQUID $^4$He. Shvets, A. D. Cryogenics, 6: 270-4(Oct. 1966).

It is relatively easy to obtain a temperature down to 1.2 to 1.0°K by pumping on liquid helium-4. To obtain lower temperatures by this method it is necessary to use fast vacuum systems, to limit the helium-II film, and to employ adsorption pumps. This review is devoted to a discussion of the different variants described in the literature for obtaining temperatures below 1°K by the method of pumping on liquid helium-4. (auth)

**2152** CRITICAL FIELDS OF SUPERCONDUCTING THIN FILMS OF TIN AND INDIUM ALLOYS. Burton, R. Cryogenics, 6: 257-63(Oct. 1966).

The penetration depths $\lambda$ in superconducting films of solutions of bismuth in tin and indium show that changes in the resistivity brought about by size effects influence $\lambda$ more than those due to varying random impurity. For the indium alloy, with residual bulk resistivity 0.68 $\mu\Omega$ cm, the weak field penetration depth at 0°K, $\lambda_0(0)$ is constant at 660 ± 40 Å for films 2,000 to 12,000 Å thick. More concentrated indium alloys become second kind superconductors when $\lambda_0(0) \sim 1{,}000$ Å with resistivity about 2.3 $\mu\Omega$ cm. On the basis of theories, the nonlocal parameters for indium are found to be, $\xi_0 = 3{,}400 \pm 400$ Å, $\lambda_L(0) = 275 \pm 35$ Å and $\rho l = 0.8 \pm 0.1 \times 10^{-11}$ $\Omega$ cm$^2$, where l is the mean free path for electrons. Evidence from supercooling data suggests that, under certain conditions, the superconducting phase might not be propagated throughout a specimen after nucleation in the surface sheath. (auth)

**2153** PROPERTIES OF HIGH-FIELD SUPERCONDUCTORS WITH MAGNETIC IMPURITIES. de Gennes, P. G. (Univ., Paris, Orsay, France); Sarma, G. Solid State Commun., 4: 449-51 (Sept. 1966).

The upper critical field H(T) of high field superconductors (bulk type II materials or films) containing a small concentration c of magnetic impurities is discussed. If the "exchange" coupling between conduction electrons and impurity spins is small with respect to the width of the conduction band, one expects in a suitable range of c values that H(T) increases with T at low temperature, goes through a maximum and decreases to zero. The low H values at low T are due to the polarization of the impurities. (auth)

**2154** TEMPERATURE DEPENDENCE OF CRITICAL FIELDS IN HIGH-FIELD SUPERCONDUCTORS. Avenhaus, Rudolf (Technische Hochschule, Karlsruhe, Ger.); Fulde, Peter. Solid State Commun., 4: 475-7(Sept. 1966).

The temperature dependence of critical fields is calculated for high-field superconductors if the phase transition into the normal state is of first order. The effect of superheating is discussed. (auth)

**2155** MAGNETIC PROPERTIES OF THIN FILMS OF SOFT SUPERCONDUCTORS. Robinson, G. (Mullard Research Labs., Redhill, Eng.). Proc. Phys. Soc. (London), 89: 633-44(Nov. 1966).

The torque method of measuring the magnetic properties of thin superconducting layers is discussed, and some results reported for experiments in which magnetic fields are applied parallel and perpendicular to the plane of evaporated films of tin, indium, and indium–tin alloy. For the parallel case critical fields and supercooling fields can be measured. For the perpendicular case magnetization curves can be derived from the torque curves. The magnetization curves were studied in some detail and comparison made with the properties of bulk type II superconductors. (auth)

**2156** CRITICAL-CURRENT BEHAVIOR IN NARROW THIN-FILM SUPERCONDUCTORS. Hunt, T. K. (Ford Motor Co., Dearborn, Mich.). Phys. Rev., 151: 325-7(Nov. 4, 1966).

Critical currents in planar thin films of tin and lead were measured as a function of temperature using very narrow strip samples. There is a critical sample width of the order of one micron above which the critical-current behavior is dominated by flux-flow processes. For narrower samples the temperature dependence of the average critical current density is in excellent agreement with the usual relation deduced from free-energy considerations, and the low-temperature values are in good agreement with the simple depairing criterion. At higher temperatures the observed critical current densities are significantly larger than the Bardeen–Rogers predictions based on calculations of the BCS energy-gap variation with current. It is proposed that in these narrow films flux vortices due to the self field of the current at the film edges are too large to enter the film and by their subsequent motion degrade the critical current. The approximate size of such vortices is calculated and good agreement with the experimental critical widths is obtained. The observation, in wide films only, of "training" phenomena similar to those seen in bulk type-II superconductors also tends to support this hypothesis. (auth)

**2157** CRITICAL MAGNETIC FIELDS IN SUPERCONDUCTING FILMS OF INDIUM. Chaudhari, R. D. (Univ. of British Columbia, Vancouver). Phys. Rev., 151: 96-100(Nov. 4, 1966).

The critical magnetic fields were measured for thin indium films of thickness 585 to 3540 Å deposited on sapphire rods at the liquid-nitrogen temperatures. For most of the films, the measurements were confined to the temperature region $0 \leq (T_c - T) \leq 0.4°K$, but for a 585-Å-thick film the measurements were extended down to 1.212°K. The critical-field data were used to test various theories of superconductivity. Near the transition temperature, the film critical field $h_c$ was found to vary as $(T_c - T)^{\frac{1}{2}}$. At lower temperatures the temperature dependence of $h_c$ is in accord with Rickayzen's model. There is also evidence that the penetration depth increases with the decrease in the film thickness. (auth)

**2158** VORTICES IN AN IMPERFECT BOSE GAS. IV. TRANSLATIONAL VELOCITY. Fetter, Alexander L. (Stanford Univ., Calif.). Phys. Rev., 151: 100-4(Nov. 4, 1966).

The translational velocity of a vortex with circulation h/m in an imperfect Bose gas is calculated by considering the time dependence of the condensate wave function corresponding to a given initial configuration of vortices. Each vortex in a system of rectilinear vortices is shown to move with the local fluid velocity at its core; a vortex ring of radius R is shown to move with velocity $(h/4\pi mR) \ln (8R/\alpha)$, where $\alpha$ is a length the order of the core size. Both results agree with the predictions of classical hydrodynamics. The theory developed provides a simple model of liquid He(II). (auth)

**2159** IMPURITY SCATTERING BY A CLASSICAL VORTEX. Fetter, Alexander L. (Stanford Univ., Calif.). Phys. Rev., 151: 112-16(Nov. 4, 1966).

The interaction of $^3$He impurities with a vortex in liquid He(II) is studied in terms of a classical model of a hard sphere in an inviscid fluid. The calculated viscous force $\mathfrak{F}'$ per unit length on a moving vortex is in reasonable agreement with the measured value of Rayfield and Reif. (auth)

**2160** QUANTIZED VORTICES IN AN IMPERFECT BOSE GAS AND THE BREAKDOWN OF SUPERFLUIDITY IN LIQUID HELIUM II. Kawatra, M. P. (New York Univ., N. Y.); Pathria, R. K. Phys. Rev., 151: 132-7(Nov. 4, 1966).

The energy and momentum associated with vortex formation in an imperfect Bose gas were computed quantum mechanically. In the computation, explicit account is taken of the boundary condition to be satisfied by the wave function at the walls surrounding the fluid. Numerical estimates of the critical velocity obtained thereby throw considerable light on the question of the most favorable location (relative to the walls) for the formation of the vortex. It is concluded that the optimum location for this formation could be well within the fluid—significantly away from the walls. (auth)

**2161** THEORY OF SUPERFLUIDITY. Cummings, Frederick W.; Johnston, James R. (Univ. of California, Riverside). Phys. Rev., 151: 105-12(Nov. 4, 1966).

A new structure for the microscopic theory of superfluid helium is presented, which is motivated by analogy with coherent radiation of ideal lasers and with the BCS theory of superconductivity. The concept of off-diagonal long-range order is employed to put these three phenomena on a common basis. The unifying concept is that the ground state is that which completely factors the reduced density matrix appropriate to the basic group. It is shown how the model predicted by this motivation can also be derived from the microscopic Hamiltonian by a quasiparticle self-consistent-field approximation. The superfluid ground state can be viewed as energy-lowering "coherent" excitations of the normal fluid. The normal and superfluid components are the direct analog of noise and signal in partially coherent radiation fields. (auth)

**2162** ENERGY GAP OF $V_3Si$. Hauser, J. J.; Bacon, D. D.; Haemmerle, W. H. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 151: 296-8(Nov. 4, 1966).

A new technique for measuring energy gaps, based on the proximity effect, was used to study $V_3Si$. A 12,000-Å $V_3Si$ film was deposited on sapphire at 1200°C by getter sputtering followed immediately by the deposition at 300°K of an 80-Å aluminum film. After oxidation of the aluminum, and delineation of the junction area with SiO, a lead film was deposited at 77°K. $V_3Si$ induces by proximity effect a gap (≃2 mV) in the aluminum film in good agreement with McMillan's theory. Furthermore, one can detect the $V_3Si$ gap itself as a dip in the relative conductance curve. In the ten samples measured, the value of the $V_3Si$ energy gap at 1°K was very close to $\Delta = 2.80$ mV, which corresponds to $2\Delta\ (0°K) = 3.8kT_c$. This result confirms the expectation that $V_3Si$ is a strong-coupling superconductor. The validity of such a technique is further shown by the fact that the lead phonon peaks are displaced by an energy corresponding to $\Delta_{Al} + \Delta_{Pb} \simeq 3$ mV. Finally, the induced gap in the aluminum remains almost unchanged by a 50-kG magnetic field and disappears only at 17°K (the resistive transition temperature of the $V_3Si$ film). (auth)

**2163** RESIDUAL ATTENUATION OF SHEAR WAVES IN ALUMINUM. Yokota, Mario; Kushibe, Hiroyuki; Tsuneto, Toshihiko (Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 36: 237-50(Aug. 1966).

The residual attenuation of shear waves is discussed in the superconducting state of pure metals. The attenuation constant at temperatures just below the transition point is calculated directly from the pseudo-potential theory in the case of aluminum and compared with the experimental data. (auth)

**2164** AMPLITUDE-DEPENDENT ULTRASONIC ATTENUATION IN SUPERCONDUCTORS. Tittmann, B. R.; Boemmel, H. E. (Univ. of California, Los Angeles). Phys. Rev., 151: 178-89 (Nov. 4, 1966).

An anomaly in the absorption of ultrasonic waves was found in some very pure superconductors and was investigated in detail in superconducting lead. It consists in a strong dependence of the absorption on the amplitude of the ultrasonic waves. The amplitude dependence is only weakly present in the normal state. The effect is found to be strongly temperature-dependent, decreases as impurities are added to the crystal, and exhibits little or no change with frequency. Deformation and annealing have a pronounced effect on the anomaly. It appears that these characteristics can be understood in terms of a model, which is proposed here, based on the assumption of a strong interaction between the conduction electrons and the dislocations in the metal crystal. The presence of weakly pinned dislocations and their motion in the field of the sound wave is assumed. In the normal state, this motion is highly damped by the conduction electrons, and therefore, the dislocations cannot contribute much to the ultrasonic absorption. In the superconducting region, this damping decreases with the same temperature dependence as the ultrasonic absorption by the electrons. The dislocations become more free to move and therefore can cause an (amplitude-dependent) absorption by themselves. The mechanism for this absorption is thought to be dislocation unpinning similar to that discussed, for example, by Granato and Lücke. (auth)

**2165** APPARENT SUPERCONDUCTING ENERGY GAP IN LEAD FROM ULTRASONIC MEASUREMENTS. Tittmann, B. R.; Boemmel, H. E. (Univ. of California, Los Angeles). Phys. Rev., 151: 189-90(Nov. 4, 1966).

The apparent superconducting energy gap in lead was obtained from ultrasonic measurements in the range of $kl \leq 1$. The gap pa-

rameter is about 5.0 $k_bT_c$ and is approximately frequency-independent over the range from 50 to 1050 Mc. (auth)

**2166** CHARACTERISTICS OF THE SOLUTIONS OF THE NONLINEAR GINSBURG–LANDAU EQUATIONS IN CYLINDRICAL SYMMETRY. Doll, Robert; Graf, Peter (Komission fuer Tieftemperaturforschung, Munich). Z. Phys., 197: 172-91 (1966). (In German).

Solutions of the nonlinear Ginzburg-Landau equations in cylindrical symmetry were computed for a type-I superconductor. From these solutions the behavior of a circular cylinder of infinite length in a magnetic field parallel to its axis was deduced. For a series of values of the magnetic field solutions are given in two cases. The first case was calculated with the assumption of no fluxoid frozen in (fluxoid quantum number n = 0), whereas in the second case a vortex with fluxoid quantum number n = 1 was assumed on the axis of the cylinder. For both series of solutions investigation of the thermodynamic stability was carried out. This and further thermodynamic considerations led to the result that in a gedankenexperiment the transition from the normal to the superconducting state and vice versa can be performed in a reversible manner. The expulsion of the magnetic field from the sample during the reversible transition to the superconducting state (Meissner effect) is also described by the solutions. Further results are the existence of a supercooled state down to a magnetic field $H_{c2} = \kappa \sqrt{2}\, H_{cb}$ and of a superheated state up to a field $H_{c1} > H_{cb}$. The value of $H_{c1}$ depends on the radius of the cylinder. If a condensation to the superconducting state takes place at a field $H_0$ where $H_{c2} < H_0 < H_{cb}$, condensation with n = 0 seems to be preferred in comparison to that with n = 1. (auth)

**2167** TUNNELING INDUCED BY LONGITUDINAL MICROWAVE PHONONS IN Al–Pb, Al–Sn, AND Pb–Pb SUPERCONDUCTING DIODES. Goldstein, Y.; Abeles, B.; Cohen, Roger W. (RCA Labs., Princeton, N. J.). Phys. Rev., 151: 349-56 (Nov. 4, 1966).

Measurements are presented of the change $\Delta I_s(V)$ in the tunneling current I(V) in superconducting diodes due to longitudinal microwave phonons as a function of voltage bias V, acoustic power, and temperature. The measurements were performed on Al–Pb, Al–Sn, and Pb–Pb diodes in the temperature range 1.3 to 2.1°K. The voltage dependence, which was heretofore thought to be described by $\Delta I_s(V) \propto d^2I/dV^2$, was found to exhibit departures from this law. This effect is most striking in Pb–Pb diodes and somewhat less apparent when one of the superconductors making up the diode is aluminum. Furthermore, the magnitude of the measured $\Delta I_s$ is much larger than one would predict from present theory. The tunnel-diode current-pulse echoes exhibit a nonexponential decay that is strongly temperature-dependent. None of this behavior is predicted by the theory. (auth)

**2168** PERSISTENCE OF ZERO SOUND IN THE POSSIBLE SUPERFLUID PHASE OF $^3$He. Leggett, A. J. (Magdalen Coll., Oxford. Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 36: 417-18 (Aug. 1966).

The following statement is proven in a general manner: if in a Fermi liquid the velocity of hydrodynamic sound c is greater than the Fermi velocity $v_F$, and the system makes a transition to any phase of the conventional generalized BCS type, then at least one undamped collective mode always exists throughout the whole temperature region in the frequency region $1/\tau \ll \omega \ll \Delta(T)$. (M.O.W.)

**2169** DIRECT OBSERVATION OF SURFACE EFFECTS IN A HYSTERETIC SUPERCONDUCTOR. Carroll, K. J. (Los Alamos Scientific Lab., N. Mex.). Phys. Lett., 23: 416-17 (Nov. 14, 1966).

A high-resolution magneto-optic technique revealed effects at the periphery of a Nb disk that may be related to surface-dependent hysteresis properties. (auth)

**2170** PULSED CRITICAL CURRENTS IN SUPERCONDUCTING FILMS. Meissner, H. (Stevens Inst. of Tech., Hoboken, N. J.). Phys. Lett., 23: 427-8 (Nov. 14, 1966).

The time dependence of the voltage in pulsed critical current experiments with concentrically mounted samples is explained by diffusion of magnetic flux through the film. The voltage is proportional to the current density and the amount of flux broken through. (auth)

**2171** HEAT FLOW BETWEEN NORMAL AND SUPERCONDUCTING REGIONS. Griffin, A.; Maki, K. (Univ. of California, San Diego, La Jolla). Phys. Lett., 23: 429-30 (Nov. 14, 1966).

A previous discussion of the heat flow between normal and superconducting regions as a tunneling process is extended to give more explicit results for time-averaged surface thermal resistance. A sharp decrease in the surface thermal resistance just below the transition temperature is predicted. It is shown that no thermoelectric effects arise in this model. Comparison is made with recent work by Andreev. (A.G.W.)

**2172** CRITICAL MAGNETIC FIELDS OF SUPERCONDUCTING SnTe. Hein, R. A. (Naval Research Lab., Washington, D. C.). Phys. Lett., 23: 435-6 (Nov. 14, 1966).

The dependence of the superconducting critical magnetic fields of the superconducting semiconductor SnTe upon carrier concentration was determined. A correlation between the occurrence of superconductivity and the appearance of heavy holes in a second valence band is noted. (auth)

**2173** MAGNETIC IRREVERSIBLE SOLUTION OF THE GINZBURG–LANDAU EQUATIONS. Fink, H. J.; Presson, A. G. (Atomics International, Canoga Park, Calif.). Phys. Rev., 151: 219-28 (Nov. 4, 1966).

The exact magnetic irreversible solution of the Ginzburg–Landau equations for a cylinder of infinite length (whose Ginzburg–Landau parameter $\kappa$ is unity and whose radius R is three coherence lengths $\xi$) in an axial magnetic field $H_0$ is presented for all values of $H_0$. Solutions for other values of $\kappa$ (0.3 to 3) and $R/\xi$ (2 to 12) are also discussed. The order parameter, the vector potential, the internal magnetic field, and the current density were determined as a function of $H_0$ and as a function of position; the total number of superconducting electrons per unit length of the cylinder and the magnetization per unit volume were determined as a function of $H_0$. This solution is magnetically irreversible and hysteretic because of persistent currents that flow in the sample perpendicular to the applied magnetic field. The magnetization is reversible only over intervals of $H_0$ over which the number of fluxoids is conserved; otherwise it is irreversible. This solution does not depend on defects and is the counterpart to Abrikosov's magnetic reversible mixed-state solution. It is dominant in thin specimens. (auth)

**2174** ULTRASONIC STUDIES OF THE SUPERCONDUCTIVITY OF DOPED TIN. Claiborne, Lewis T.; Einspruch, Norman G. (Texas Instruments Inc., Dallas). Phys. Rev., 151: 229-37 (Nov. 4, 1966).

Detailed information concerning the anisotropy of the effective limiting superconducting energy gap $\Delta(0)$ of doped Sn was obtained from measurements of the temperature dependence of the attenuation of compressional ultrasonic waves. Earlier results for the In-doped Sn system were confirmed for other impurities, and analysis of the results was made in terms of recent developments in the theory of dirty superconductivity. Measurements were made for the sound-propagation vector q parallel to the [001], [110], and [100] directions in single crystals of In-, Cd-, Sb-, and Bi-doped Sn with impurity concentrations ranging from ~1 to 5,000 ppM. The measured anisotropy between the [110] and [001] directions for pure Sn is ~20% of the average energy gap. It is found that this anisotropy is reduced to ~2% for values of the inverse resistivity ratio $\rho \gtrsim 10^{-2}$ and for $\Delta T_c > 15$ m°K. BCS theory, which was developed for isotropic, weak-coupling superconductors, is applicable to the most heavily doped samples; it is found that the energy gap (~1.76 $k_BT_c$) and the temperature dependence of ultrasonic attenuation are in agreement with the predictions of the theory. By comparing the energy-gap measurements from tunneling data with the energy gap obtained from ultrasonic-attenuation data, it is possible to demonstrate that the temperature dependence of the attenuation gives a measure of more than one energy gap. In addition to the gap obtained from the attenuation data at low temperatures, a larger gap can be observed near $T_c$. From tunneling data, the larger gap for q|| [001] is (1.9 ± 0.05) $k_BT_c$; the ultrasonic determination yields (1.92 ± 0.02) $k_BT_c$. In addition, the temperature dependence of the larger gap is obtained near $T_c$ and is compared with BCS theory. For $[1 - T/T_c]$ ranging from ~$4 \times 10^{-2}$ to ~$4 \times 10^{-1}$, it is found that the BCS-predicted approximation, $\Delta(T)/\Delta(0) = 1.74\,[1 - T/T_c]^{1/2}$, is accurate to ~2%. (auth)

**2175** CALCULATION OF THE ELECTROMAGNETIC ABSORPTION EDGE IN SUPERCONDUCTING ALLOYS. Ginsberg, D. M. (Univ. of Illinois, Urbana). Phys. Rev., 151: 241-5 (Nov. 4, 1966).

The theoretical shape of the electromagnetic absorption edge in superconducting alloys is calculated. The results agree with the experimental data better than those calculated much more easily by assuming the alloys are in the Pippard limit or the London limit. Nevertheless, the experimental absorption edges are somewhat steeper than the calculated ones. (auth)

**2176** THEORY OF TRANSITION TEMPERATURES OF DOUBLE-LAYER SUPERCONDUCTORS (PROXIMITY EFFECT). Moormann, Wichen (Univ., Goettingen, Ger.). Z. Phys., 197: 136-58 (1966). (In German).

A theory of the transition temperature of superconducting, superposed films is given by generalizing the methods of de Gennes

and Werthamer. It is shown that the transition temperature of nonhomogeneous superconductors obeys a general rule, which is formally of the same kind as the corresponding formula for homogeneous superconductors and is valid for all mean free paths. The results of Werthamer follow analytically in the dirty limit if the transition temperatures of the superposed films are nearly equal, but there is numerical agreement for almost all superconductor–superconductor films. In the thin film limit and for normal conductor–superconductor films there are essential deviations. The theory is in good accord with the experimental data. By calculating the unknown interaction constant of copper from the experimental transition temperatures of superposed Cu–Pb films one gets for copper a transition temperature of the order of $10^{-2}$°K. (auth)

**2177** METALLIC CONDUCTIVITY AND SUPERCONDUCTIVITY IN SOME SILVER CLATHRATE SALTS. Robin, M. B.; Andres, K.; Geballe, T. H.; Kuebler, N. A.; McWahn, D. B. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev. Lett., 17: 917-19(Oct. 24, 1966).

Previous studies indicate that argentic oxide salts $(Ag_7O_8)^+X^-$ are cage structures (clathrates) which consist of face-sharing $Ag_6O_8$ polyhedro containing the $X^-$ anions at their centers. It was found that salts with $X^-$ equal to $NO_3^-$, $F^-$, and $BF_4^-$ are the first examples of clathrates which exhibit metallic conductivity and are superconducting at 1.04, 0.3, and 0.15°K, respectively. In addition, the electrical resistivity of $Ag_7O_8NO_3$ as a function of temperature shows several anomalies, with abrupt changes at 220, 180, and 110°K. A curve of resistivity versus temperature for a single crystal of $Ag_7O_8NO_3$ is shown. Results indicate that regardless of crystal morphology, $Ag_7O_8NO_3$ becomes superconducting at 1.04°K, with the needles showing the sharper transition. The superconductivity of nitrate salt was investigated in detail, and the results show that it is typical of a type-II superconductor with a high value of the Landau–Ginzberg parameter $\kappa$. (J.H.M.)

**2178** AMPLITUDE-DEPENDENT ULTRASONIC ATTENUATION IN NORMAL AND SUPERCONDUCTING LEAD. Hikata, A.; Johnson, R. A.; Elbaum, C. (Brown Univ., Providence). Phys. Rev. Lett., 17: 916-17(Oct. 24, 1966).

Several features of the amplitude-dependent attenuation both in the normal and superconducting states are presented. The experiments were carried out using longitudinal waves propagating along the direction of lead single crystals. The frequencies covered were 10, 20, and 30 Mc/sec. Measurements were made under the following conditions: at 4.2°K with no magnetic field (superconducting state), at 4.2°K with a magnetic field larger than the critical field (normal state), at 8°K (normal state), at 77°K, and at 294°K. The results are consistent with the amplitude-dependent attenuation due to dislocations treated by Rogers [J. Appl. Phys. 33, 781 (1962)], who extended the Granato–Lücke theory to higher strain amplitudes. (J.H.M.)

**2179** STABILIZED Nb–Zr STRIP AND ITS USE IN LARGE MAGNETS. Hoag, Ethan D. (Avco Everett Research Lab., Everett, Mass.). IEEE (Inst. Elec. Electron. Eng.) Trans. Magnet., MAG-2: 315-18(Sept. 1966).

Obstacles in the use of rolled Nb–Zr strip as a practical material for conductors in large superconducting magnets are discussed. How the 3 main obstacles to the use of this strip superconductor in magnets have been overcome is described. These 3 problems are as follows: (1) Anisotropy of critical current with magnet field direction: Nb–Zr strip in its as rolled state displays extreme anisotropy with the peak critical current occurring when the field is parallel to the rolling plane, making it difficult to use in anything but long solenoids. This effect was drastically reduced by certain annealing procedures so that the minimum critical current is about 50% of the peak value instead of less than 1% for as rolled strip. (2) Truncation of the anisotropy curves with wide strips: With strips >1 mm in width the peak of the anisotropy curve becomes progressively more truncated or chopped off as the width is increased. By stabilizing with a copper backing, however, truncation can be completely eliminated so that the strip can be used with equal effectiveness in any width. (3) Coil degradation effect: The failure of superconductors in general to operate at their short sample critical currents when wound into a magnet is well known. Strip Nb–Zr is worse than wire. However, when stabilized with copper to eliminate truncation, the coil degradation is also eliminated provided sufficient cooling passages are provided to remove the Joule heating released by flux jumps and eddy currents. Two actual coils (12.7 cm ID, 1.25 $Wb/m^2$, and 2.54 cm ID, 3 $Wb/m^2$) constructed with this stabilized material operate at the short sample critical currents. These developments have made it possible to construct large magnets from Nb–Zr strip and predict their performance in advance from short sample data. The high critical currents afforded by operation at the short sample critical currents permit designs using only a fraction of the material necessary in unstabilized coils. (BBB)

**2180** THERMAL STABILITY FOR Ti-22 AT. PERCENT Nb SUPERCONDUCTING CABLES AND SOLENOIDS. Whetstone, C. N.; Chase, G. G.; Raymond, J. W.; Vetrano, J. B.; Boom, R. W.; Prodell, A. G.; Worwetz, H. A. (Atomics International, Canoga Park, Calif. Brookhaven National Lab., Upton, N. Y.). IEEE (Inst. Elec. Electron. Eng.), Trans. Magnet., MAG-2: 307-10(Sept. 1966).

Experiments were performed which indicate that critical currents for stabilized cables are essentially independent of superconductor critical temperature ($T_c$). It is shown that the critical temperature rise for a conductor in a liquid helium bath is determined primarily by surface heat transfer conditions, that reversible supercurrent recovery levels are only slightly lower than short sample critical currents, and that a copper limited region completely independent of $T_c$ exists. Thermal stability and supercurrent recovery levels are reported for composite copper, Ti–22 at. % Nb cables. Cable sizes vary from 0.06 to 0.17-in. dia and current levels from 200 to 1800 A. Magnet and small coil tests show that cable magnet performance is consistent with short gap cable tests. It is shown that thermal stability for cables in liquid helium occurs only for temperature rises less than ~0.8°K; thus, the critical temperature of the superconductor is not an important factor in the design of totally protected solenoids. Magnet design recommendations are made which define the limit for stabilized currents as the superconducting critical current or the copper-limited current, whichever is lower. Copper-limited values are determined by cooling conditions and normal cable resistance. (BBB)

**2181** USE OF SUPERCONDUCTORS WITH VARIED CHARACTERISTICS FOR OPTIMIZED DESIGN OF LARGE-BORE HIGH-FIELD MAGNETS. Schrader, E. R.; Thompson, P. A. (Radio Corp. of America, Harrison, N. J.). IEEE (Inst. Elec. Electron. Eng.) Trans. Magnet., MAG-2: 311-15(Sept. 1966).

Problems encountered in the design of magnets using superconductors are discussed, particularly as applied to vapor-deposited $Nb_3Sn$ ribbon conductors in which variation in type and thickness of the $Nb_3Sn$ deposit controls the maximum supercurrent for a given magnetic field, and the normal (nonsuperconductive) metal coating controls stability against the deleterious effects of flux jumps. An important consideration for large-bore high-field magnets is the structure itself, which must be designed for adequate liquid-helium access and axial force containment. Optimization of the complete design involves an iterative process in which selection of the superconductors is made self-consistent with the corresponding local magnetic fields, conductor currents, required radial-force containment, and overall mechanical constraints. General solutions to these problems are described and the iterative method of design is illustrated by calculations on a 15-cm-bore 15-tesla magnet, using superconductors with varied characteristics. The mechanical strength, current-carrying capabilities, and electromagnetic stability of the $Nb_3Sn$ ribbons are independently adjustable to produce the various conductors required. An existing 8.4-cm-bore 8-tesla magnet is used to illustrate a modular-type construction. Use of the iterative process to satisfy sometimes conflicting mechanical, electromagnetic, and cryogenic requirements is detailed in a review of the design of the 15-cm-bore 15-tesla superconductive magnet, now under construction. (BBB)

**2182** THE PERFORMANCE OF STABILIZED Nb–Zr WIRE IN COILS. Stekly, Z. J. J. (Avco Everett Research Lab., Everett, Mass.). IEEE (Inst. Elec. Electron. Eng.) Trans. Magnet., MAG-2: 319-22(Sept. 1966).

A conductor is described, together with the principles used in its development, which allows a detailed engineering design to be carried out on a superconducting coil of practically any size and shape with assurance that the ultimate performance will vary no more from the predicted performance than by standard engineering deviations of a few percent. The basic conductor used is a copper strip 0.040 by 0.500 in. which has imbedded in it nine 0.010-in. dia heat treated Nb–Zr wires. Typically this conductor can carry 1800 A (200 A per wire) at 20 kG and 720 A (80 A per wire) at 40 kG and has a current-carrying capacity which decreases linearly with increasing magnetic field. (Since the amount of conductor required to produce a given magnetic field is inversely proportional to the current the conductor carries, the use of heat-treated Nb–Zr, which has a much higher current carrying capacity, results in a very significant economic gain.) When measurements are taken on short samples of this conductor, the voltage across the sample remains equal to zero up to the critical current, and if enough cooling is present the voltage rises gradually at higher currents. Also considered is the performance of the stabilized conductor

when wound into magnets. Several magnets were built using the stabilized Nb–Zr strip. These coils include round as well as saddle-shaped coils and produce magnetic fields over dimensions of a few inches to a few feet. The performance of these magnets is discussed with regard to the current-carrying capacity of the conductor before the appearance of resistance. In all magnets tested the appearance of resistance did not precipitate a quench. The resistance appeared at a predetermined value of current and upon lowering the current it disappeared at essentially the same current as it had appeared. (BBB)

**2183** TOLERANCE ANALYSIS OF THE SUPERCONDUCTING CONTINUOUS-SHEET MEMORY. Atherton, D. L.; Tyler, A. R. (Ferranti-Packard Electric Ltd., Toronto). Proc. Inst. Elec. Eng. (London), 113: 1575-9(Oct. 1966).

A simple tolerance analysis of the superconducting continuous-sheet memory predicts maximum tolerances of ±14%, but higher tolerances have been measured. This analysis considers the implications of some of the simplifying assumptions traditionally made. More detailed considerations can either increase or decrease the predicted tolerances. The justification of the usual current switching analysis is examined, and it is concluded that a maximum average energy-density switching criterion should be used but that critical current switching has the dubious though useful advantage of simplicity. Since calculated tolerances depend on the simplifications assumed, any conclusions regarding the ultimate feasibility of proposals for the continuous-sheet memory which are based on calculated tolerances are ill founded. There seems to be no fundamental reason why the measured operating tolerances cannot be increased beyond 14% if the fabrication processes and parameters governing them can be elucidated and controlled. (auth)

**2184** INFLUENCE OF LATTICE IMPERFECTIONS ON SUPERCONDUCTIVITY OF MERCURY. Fechner, Dieter; Hasse, Joerg (Technische Hochschule, Karlsruhe, Ger.). Z. Phys., 195: 380-8(1966). (In German).

The variation of the transition temperature with residual resistance and the longitudinal critical magnetic field was measured on wires of $\alpha$-Hg, cold worked at 4.2°K. No transformation into $\beta$-Hg during cold working was found. An order of magnitude value was obtained for the anisotropy parameter $\langle a^2 \rangle \approx 0.005$. The continuous decrease of the transition temperature and the increased critical fields are discussed in terms of the low Debye-temperature of Hg. (auth)

**2185** STATIC SPIN SUSCEPTIBILITY OF SUPERCONDUCTORS WITH P-PAIRING AND THE COLLECTIVE EXCITATIONS. Czerwonko, J. (Univ., Wroclaw). Bull. Acad. Pol. Sci., Ser. Sci. Math. Astron. Phys., 14: 407-15(1966).

The influence of collective excitations on the static spin susceptibility of superconductors, observed in the Knight's shift measurements, is investigated. The investigation will concern only temperatures close to absolute zero. (J.H.M.)

**2186** EFFECTIVE LONG-WAVELENGTH INTERACTION OF $^3$He ATOMS DISSOLVED IN SUPERFLUID $^4$He. Baym, Gordon (Univ. of Illinois, Urbana). Phys. Rev. Lett., 17: 952-4(Oct. 31, 1966).

$^3$He atoms, when dissolved at low concentrations in superfluid $^4$He, have a weak residual interaction which is attractive at small momentum transfers. The interaction is weak compared with the interatomic forces in the system. The physical reason that the effective interaction is small is that in the solution the $^3$He displaces the $^4$He; however, the force fields of $^3$He atoms and $^4$He atoms are identical and only the differences in zero-point motion and statistics of the $^3$He atom from the $^4$He background produce a residual interaction. A theoretical calculation of $V_0$, the $k \to 0$ limit of the effective interaction, is presented. (W.D.M.)

**2187** SURFACE STATES AND ADDITIONAL STRUCTURE IN THE McMILLAN–ANDERSON MODEL FOR THE TOMASCH EFFECT. Wolfram, T.; Einhorn, M. B. (North American Aviation Science Center, Thousand Oaks, Calif.). Phys. Rev. Lett., 17: 966-8(Oct. 31, 1966).

The McMillan–Anderson model was solved exactly in order to determine what additional structure is contained in the model. Some of the features of the exact solution were: only the fundamental period occurs in the exact solution for the change in the density of states, $\delta N(\omega)$; an additional oscillatory term with the fundamental period but phase shifted by $\pi/2$ from the first Born term and of comparable amplitude occurs in $\delta N(\omega)$ at energies near the gap; surface eigenstates exist both below and above the energy gap. (W.D.M.)

**2188** THERMAL CONDUCTIVITY OF A SUPERCONDUCTOR IN THE MIXED STATE. Dubeck, Leroy William. New Brunswick, N. J., Rutgers–The State Univ. of New Jersey, 1966. 185p. Thesis.

Thermal conductivity and magnetization measurements were made on specimens of indium containing bismuth impurities, on a specimen of pure niobium, and on a specimen of niobium containing oxygen impurity. These specimens had values of the Ginzburg–Landau parameter, $\kappa$, greater than .707 and thus were type II superconductors. The thermal conductivity of type II superconductors assumes a lower value in the mixed state than in either the normal or superconducting states. The minimum is caused by the different effect of the applied magnetic field upon the phonon and electron thermal conductivities in the mixed state. As the applied field is increased beyond the lower critical field the phonon conductivity decreases faster than the electronic conductivity increases. Many of the observed features may be described by a model in which an average, field dependent, energy gap is used to evaluate the phonon and electron conductivities as a function of the applied field. This analysis yields semi-quantitative agreement with experiment for indium alloys in the region between the lower critical field and the thermal conductivity minimum. There is a marked anisotropy observed near the lower critical field when the field direction is changed with respect to the direction of heat flow. This anisotropy is believed to be caused by the scattering of phonons by fluxoids. A much smaller anisotropy exists in the thermal conductivity minimum and is probably caused by fluxoid scattering of electrons. Near the upper critical field the thermal conductivity of impure type II superconductors is a linear function of the applied field. There is qualitative agreement between experiment and the theory of Caroli and Cyrot which is based on the fact that impure type II superconductors are gapless near the upper critical field. These calculations apply only for superconductors with short electronic mean free paths. The intrinsic type II superconductor niobium does not obey the predictions of either the average energy gap analysis or the theory of Caroli and Cyrot; when impurities are added its behavior becomes similar to that of the niobium–bismuth alloys. (Dissertation Abstr.)

**2189** THERMAL CONDUCTIVITY OF LIQUID $^3$He. Connolly, John Irving. Urbana, Ill., Univ. of Illinois, 1965. 60p. Thesis.

The thermal conductivity of liquid $^3$He at low pressure from 0.055 to 0.47°K, at 99.8 psi from 0.055 to 0.75°K, and 396.8 psi from 0.055 to 0.87°K was measured. At all pressures and at sufficiently low temperatures the thermal conductivity increases with decreasing temperature. At low pressures the data agree with the data of Anderson et al. which, at temperatures lower than those investigated in this experiment, agreed with the $T^{-1}$ temperature dependence predicted by Fermi liquid theory. At high temperatures the conductivity increases slowly with increasing temperature. Near 1°K the effect of pressure on the conductivity, large at lower temperatures, has become very small. At all temperatures the conductivity decreases with increasing pressure. As the pressure is increased the minimum in the conductivity occurs at a lower temperature. These data have provided an experimental basis for theories of transport properties at temperatures too high for the simple Fermi liquid picture to be valid but in a region where degeneracy effects are still important. (Dissertation Abstracts)

**2190** HEAT TRANSFER FROM CYLINDERS TO A SATURATED LIQUID HELIUM II BATH. Holdredge, Russell Morton. Lafayette, Ind., Purdue Univ., 1965. 149p. Thesis.

The heat transfer from two cylinders 0.145 and 0.245 cm in diameter was measured for superfluid helium-II baths of 1.8, 1.96, and 2.1°K. Temperature differences between the test section surface and bath ranged from 0.01 to 165°K. A limited amount of helium-I data was obtained for comparison purposes. For small heat fluxes the dependence of the thermal resistance upon temperature difference followed the Khalatnikov theory of the Kapitza resistance and was proportional to the bath temperature raised to the $-n$ power. The value of n was approximately 5 and 3 for the 0.145- and 0.245-cm test sections. Other investigators have found n to be between 2.6 and 4.2 for flat plates, while 3 is predicted by theory. For the 0.145-cm test section the thermal resistance was approximately one-half that of the 0.245-cm test section. Immersion depth of the total section was not a parameter. For intermediate heat fluxes and temperature differences of 0.08°K for the 2.1 bath to 0.3°K for the 1.8°K bath the dependence of the resistance upon temperature difference deviated from the Khalatnikov theory, and immersion depth became a parameter. The difference due to diameter became less and reversed just before the transition to film boiling. No nucleate boiling was observed. For the non-film boiling results some day-to-day variation in results was observed, but no hysteresis effects of the type found in helium I occurred. The transition to film boiling, which was accompanied by a temperature jump, occurred at temperature differences which

were on the order of 1.5 to 2°K. The heat fluxes at transition were slightly less for the larger test section, and the heat fluxes for the 1.96°K bath temperature were larger than for the other bath temperatures. The burnout heat flux was greatly influenced by immersion depth, which is a unique characteristic of helium II. For helium-II the immersion depth, bath temperature, and test section diameter were all significant parameters in film boiling, while no effect of immersion depth was observed in helium-I. The film boiling correlations of Breen and Westwater and of Bromley, while successful for helium-I, were unsuccessful in helium-II. The correlation of Rivers and McFadden, which was derived for superfluid helium, successfully correlated the helium-II film boiling results. The value of $N_{Nu}/N_{Gr}^{x}$ for film boiling in helium-I and helium-II appeared to approach the same limiting value for large temperature differences. (Dissertation Abstracts)

# Plasma and Thermonuclear Physics

**2191** (TID-23318) QUARTERLY PROGRESS REPORT NO. 82. Zimmermann, H. J.; Harvey, G. G. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics). July 12, 1966. Contract AT(30-1)-3581. 309p. (RLE-QPR-82). Dep. mn. CFSTI $7.00 cy, $1.50 mn.

Research results are reported on general physics in terms of molecular beams, molecular collisions, microwave spectroscopy, radio astronomy, solid-state microwave electronics, optical and infrared spectroscopy, noise in electron devices, physical electronics and surface physics, physical acoustics, and electrodynamics of moving media. Separate abstracts were prepared for six sections on plasma physics and for one paper on "Neutrality of the Neutron." (W.D.M.)

*For abstracts of individual sections see: 2077, 2192, 2205, 2206, 2228, 2229, and 2390.*

**2192** (TID-23318, pp 127-72) PLASMAS AND CONTROLLED NUCLEAR FUSION. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

Research on plasmas and controlled nuclear fusion is summarized in terms of system C (ion-cyclotron wave generation), system D (beam-plasma discharge), electron density measurements for beam-plasma systems with a 4-mm interferometer, spectrographic measurement of electron temperature in the beam-plasma discharge, computer simulation of the beam-plasma discharge, theory of plasma excitation by a line-charge source, cross-field beam-plasma interactions, dynamics of the plasma boundary, generation of a quiescent arc plasma, and universal instability in a collision-dominated plasma. (W.D.M.)

**2193** ANOMALOUS PULSED MICROWAVE EMISSION AT CYCLOTRON FREQUENCY IN PARTIALLY IONIZED PLASMAS. Tanaka, Shigetoshi (Univ. of Nagoya, Japan). J. Phys. Soc. Jap., 21: 2028-35(Oct. 1966). (IPPJ-25).

An extension of the study of the anomalous microwave emission at cyclotron frequency in partially ionized plasmas, which has been reported previously, is described. It is shown that the emission is not stationary with respect to time. It is emitted pulsively at some definite phase of the low frequency oscillation, which is present in the dc discharge plasma. The peak power of its pulsed emission is extremely large and the power obtained is larger by $2 \times 10^4$ times than that of the blackbody, if the plasma is in thermal equilibrium. It is inferred that such emission can be observed at the cathode side of the plasma, but can not at the anode side. (auth)

## Confinement and Heating of Plasma

*Refer also to abstracts 2206 and 2826.*

**2194** (N-66-21355) CYLINDRICAL SHOCK MODEL OF THE PLASMA PINCH. Rowell, Glen A. (Princeton Univ., N. J. Guggenheim Labs. for the Aerospace Propulsion Sciences). Feb. 1966. 54p. (NASA-CR-71412). CFSTI $3.00 cy, $0.50 mn.

A model of the plasma pinch is formulated which represents the imploding current sheet as an impermeable piston that drives a gasdynamic shock wave ahead of it toward the axis of the discharge. This cylindrical piston-shock problem is solved without further reference to electromagnetic effects. First the Lagrangian equations are solved for a parabolic shock trajectory in the r-t plane yielding a first and second approximation for the piston trajectory. To determine the accuracy of the approximation, the same problem is solved for a straight shock in the r-t plane by the method of characteristics in using the Eulerian formulation. It is found that the solutions given by the two methods compare exactly where a solution to the problem using the method of characteristics exists. The results are in qualitative agreement with relevant experimental observations. (auth)

**2195** (NP-16363) DIFFUSION OF A WEAKLY IONIZED PLASMA IN A MAGNETIC FIELD. Polman, Jan (Groningen Rijksuniversiteit (Netherlands)). 1966. 108p. Dep. mn.

Thesis.

A theoretical description is given of an axially decaying plasma based on the assumption that the plasma transport processes are controlled by elastic collisions between charged particles and neutrals. The plasma instabilities involved are discussed. Experimental arrangements and diagnostic methods are described. (M.O.W.)

**2196** (NP-tr-1429) A STELLARATOR TYPE TOROIDAL MAGNETIC TRAP WITH EXTERNAL PLASMA INJECTION. Berezhetskii, M. S.; Grebenshchikov, S. E.; Zverev, N. M.; Shpigel, I. S. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). Translated for Culham Lab., Abingdon, Eng., from report A-104. 15p. (CTO-315). Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $1.60 fs, $0.80 mf.

The main physical and design aspects of a stellarator type toroidal magnetic trap with external plasma injection, are described. A justification is put forward for choosing a helical magnetic field with n = 2. The magnetic system, power supply, and vacuum system are also described. (auth)

**2197** (NP-tr-1430(Draft)) NON ADIABATIC INJECTION OF PLASMA INTO THE L-2 STELLARATOR WITH n = 2. Fedyanin, O. I.; Kholkov, U. V.; Zubkov, V. L. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). Translated for Culham Lab., Abingdon, Eng., from report A-89. 22p. (CTO-312(Draft)). Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $2.60 fs, $0.86 mf.

Results are reported of an experimental investigation of the possibility of injection into, and filling, a closed toroidal trap with helical magnetic field with n = 2 (L-2). The plasma is injected using the programmed magnetic field method. The injected plasma is captured in the trap which it fills within 150 to 200 μsec; the quasi-stationary plasma density on establishment of equilibrium, is $\sim 2.3 \times 10^{10}$ cm$^{-3}$. (auth)

**2198** CORRELATION OF DENSITY FLUCTUATIONS AND DIFFUSION IN A PLASMA. Tsukishima, T.; McLane, C. K. (Inst. for Telecommunication Sciences and Aeronomy, Boulder, Colo.). Phys. Rev. Lett., 17: 900-1(Oct. 24, 1966).

An experimental determination is reported of the lf spectrum of the density correlation function. It is shown that it is of the expected form and that it gives a diffusion coefficient of the right order of magnitude. (M.O.W.)

**2199** RESISTIVE DIFFUSION OF CESIUM PLASMA IN A STELLARATOR. Berkl, E.; Eckhartt, D.; Gierke, G. v.; Grieger, G. (Institut fuer Plasmaphysik, Garching, Ger.). Phys. Rev. Lett., 17: 906-10(Oct. 24, 1966).

Experiments are described in which surface recombination losses within the plasma volume were made negligibly small by minimizing the surfaces of the supports of the plasma source. In this way it was shown that the radial transport of the plasma is governed by resistive diffusion. (M.O.W.)

**2200** ON THE STATIONARY STATE OF A PLASMA IN MAGNETOSTATIC AND POTENTIAL FIELDS. Klima, R. (Inst. for Plasma Physics, Czechoslovak Academy of Sciences, Prague). Phys. Lett., 23: 329-30(Oct. 31, 1966).

The approximate theory of stationary collisionless plasma in which an electrostatic field and some additional potential force field act next to an inhomogeneous magnetostatic field, is presented. The results obtained are applicable, e.g., to the gravitational and high-frequency electromagnetic fields. (auth)

**2201** BEHAVIOR OF A CHARGED PARTICLE IN A CUSP FIELD. Shinano, Kunizo; Ito, Hiroshi (Osaka Univ.). J. Phys. Soc. Japan, 21: 1822-9(Sept. 1966).

The motion of a charged particle in a biconical cusp field was calculated. A precise description of the orbits of the particle realizable in the strong field region of the cusp was obtained using cylindrical coordinates. Nonadiabatic behavior of the particle starting from one point cusp, traversing the midplane and reaching the other point cusp is investigated. In such a motion, the change in the magnetic moment of the particle is given by a function of the parameter K(the ratio of the canonical angular momentum to the mass of the particle), the initial value of the magnetic moment $\mu_1$ and the r-coordinate of the point where the particle passes the midplane. The farthest point the particle can reach under a certain injection condition is determined by the values of K and $\mu_1$. The analytical results are compared with computer calculations. (auth)

## Diagnostics of Plasma

*Refer also to abstracts 2074, 2228, and 2233.*

**2202** (AD-641145) ABSORPTION AND EMISSION COEFFICIENT DETERMINATION BY A ZONAL RING TECHNIQUE IN A

CIRCULAR CYLINDRICAL PLASMA COLUMN. Oss, J. P. (Aerospace Research Labs., Wright-Patterson AFB, Ohio). June 1966. 63p. (ARL-66-0110). CFSTI $3.00 cy, $0.75 mn.

An automated data acquisition and reduction system is described for obtaining absorption and emission coefficients in a circular cylindrical plasma column. The data reduction is based on a zonal ring method with the absorption coefficient accounted for in the emission coefficient calculations. Computer programs are included at the end of the report. (auth)

**2203** (N-66-21655) CESIUM PLASMA SPECTROSCOPY. ELECTRON NUMBER DENSITY MEASURED BY STARK SHIFT OF SPECTRAL LINES. Final Report. Majkowski, R. J.; Donohue, R. J. (General Motors Research Labs., Warren, Mich.). Jan. 14, 1966. Contract NAS3-6470. 43p. (NASA-CR-71394). CFSTI $3.00 cy, $0.75 mn.

The widths and shifts of atomic spectral lines were measured for an rf (8 Mc) electrodeless cesium discharge in which the electron density was varied from 0.5 to $3 \times 10^{14}$ $cm^{-3}$ with a temperature range from 2500 to 3100°K. The measured shifts were from 0.008 to 1.4 Å and shift to width ratios were from 0.33 to 1.40. These measurements were compared to theoretical predictions in order to evaluate the shift measurement as a diagnostic method to measure electron density. (auth)

**2204** (SU-247-11) TEMPERATURE MEASUREMENT AND INTERNAL FLOW HEAT TRANSFER ANALYSIS FOR PARTIALLY IONIZED ARGON. Incropera, F. P. (Stanford Univ., Calif. Nuclear Technology Lab.). Aug. 1966. Contract AT(04-3)-247. 179p. Dep. mn. CFSTI $5.00 cy, $1.75 mn.

From a review of the arc jet literature, three techniques are found to be best suited to the task of plasma jet temperature measurement. Two of these techniques are spectroscopic and are referred to as the Larenz and two-line methods, and the third is calorimetric and operates by insertion of a probe in the plasma stream. An uncertainty analysis performed on each of the selected methods indicates that the most suitable spectroscopic technique is one which combines the ion-neutral, two-line method with the Larenz method. Spectroscopic and calorimetric probe measurements of temperature profiles in the same argon plasma source agree to within 4 percent, which is also the expected uncertainty predicted from the analysis. For all of the measurements made the values of the flow rate and enthalpy obtained from integration of local measurements over the jet cross-section agree with the known flow rate and bulk enthalpy to within 10 percent. Criteria are proposed which may be used to select the diagnostic technique best suited to a particular application. Measurements of plasma jet acoustic power and mixing length, as well as visual and photographic studies, verify the existence of laminar, transitional, and turbulent flow regimes. Using a Reynolds number based on gas properties at the nozzle wall reveals that passage from a laminar to a transitional jet occurs at approximately the same Reynolds number as transition from laminar to turbulent flow for conventional fluids in a circular duct. This observation suggests that the principal source of turbulence in the plasma jet stems from turbulence generation at the nozzle walls. An analysis of the laminar flow of a plasma in the entrance region of a circular tube was performed using an implicit finite-difference scheme. Numerical results were obtained for an argon gas having a linear enthalpy and cubic velocity profile at the tube entrance. At the low temperature limit of the analysis, the friction factor is in agreement with previous results; and in all but a very small region near the tube entrance the local Nusselt number agrees with the Nusselt number for constant property, fully-developed flow to within approximately 17 percent. The implication of this result is remarkable when considered in light of the number of effects which influence the local convective heat transfer. (M.O.W.)

**2205** (TID-23318, pp 187-91) SPONTANEOUS RADIOFREQUENCY EMISSION FROM HOT-ELECTRON PLASMAS. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

Results of a preliminary investigation of the enhanced cyclotron radiation observed in the afterglow of an experimental electron-cyclotron discharge apparatus are reported. Typical plots of the microwave emissions from the plasma are illustrated. A small-signal energy expression is formulated for instabilities in extraordinary waves across a magnetic field. (W.D.M.)

**2206** (TID-23318, pp 193-206) INTERACTION OF LASER RADIATION WITH PLASMAS AND NONADIABATIC MOTION OF PARTICLES IN MAGNETIC FIELDS. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

Results on laser radiation Thomson-scattered by an electron beam are summarized. Considerable progress was made in determining the modes of particle escape from the nonadiabatic trap previously described. A new diagnostic, that of ion collection, was added, and the problems of detector sensitivity were solved by the development of a fast low-noise miniaturized preamplifier. A new 15-period corkscrew having a maximum perturbing field of 2% was installed. Construction, operation, and results are described. (W.D.M.)

**2207** COMPARISON OF MICROWAVE AND PROBE METHODS OF PLASMA DIAGNOSTICS. Sicha, M.; Gajdusek, J.; Veprek, S. (Charles Univ., Prague). Brit. J. Appl. Phys., 17: 1511-14(Nov. 1966).

A comparison of three methods of plasma diagnostics (microwave toroidal resonator, cylindrical resonator and probe methods) is given. The agreement found for values of electron concentrations in a positive glow discharge column in neon, obtained by means of these methods may be regarded as good, considering the precision with which the basic parameters of the plasma are determined. In addition, all the data necessary for construction and use of the toroidal resonator used in the measurements are presented. (auth)

**2208** RESONANCES OF RADIO-FREQUENCY PROBE IN A PLASMA. Ikezi, Hiroyuki; Takayama, Kazuo (Univ. of Nagoya, Japan). J. Phys. Soc. Jap., 21: 2021-8(Oct. 1966).

An rf probe experiment was carried out with a low density plasma, the resonances of the probe impedance were studied. The resonances were observed in a frequency range between the sheath-plasma resonance and the plasma frequencies. The mechanism of these additional resonances is discussed. It is shown that a finite electron temperature will introduce these resonances in addition to the sheath-plasma resonance. Choosing some artificial density distributions in front of the probe, the frequency dependence of the resonances is explained qualitatively. (auth)

**2209** OBSERVATION OF THE ION RESONANCE BY AN RF PROBE. Kato, Kiyoe; Ogawa, Kiyoshi; Kiyama, Satoru; Shimahara, Hiroko (Electrotechnical Lab., Tokyo). J. Phys. Soc. Jap., 21: 2036-9(Oct. 1966).

Observations have been made of ion resonances which show a minimum in the dc current of an rf probe near the plasma-ion frequency. $f_{pi} = (Ne^2/\pi M)^{1/2}$. The hot-cathode discharge tubes used were filled at a pressure of $3 \sim 10^{-3}$ mm Hg with one of the following gases: He, Ne, Ar, and Hg. The behavior of the ion resonance was observed, in comparison to the electron resonance. A frequency variation proportional to the square root of the plasma number density was observed in the ion resonance as in the electron resonance, but the dependence of the frequency on the probe voltage was different. In the former the dependence of the frequency on the ion mass agrees with the formula for the plasma-ion frequency. (auth)

**2210** ANOMALOUS SKIN DEPTH IN A GASEOUS PLASMA. Kofoid, Melvin J. (Boeing Scientific Research Lab., Seattle); Dawson, John M. Phys. Rev. Lett., 17: 1086-8(Nov. 21, 1966).

The penetration of an oscillating magnetic field into a cylindrical plasma of diameter 5 cm and length 40 cm was investigated. The gases used in the experiment were Kr and Xe; the applied oscillating field had peak values which ranged from 50 to 160 G at the surface of the plasma; the frequency of the applied field was 510 kc. Magnetic probes were used to measure the oscillating field at the axis. A double probe was used to measure the electron temperature and density. (W.D.M.)

**2211** ELECTRON GUN FOR GAS DYNAMIC AND PLASMA MEASUREMENTS. Zelikson, D. L.; Trokhan, A. M. Izmeritel. Tekh., No. 8, 21-3(Aug. 1966). (In Russian).

An electron gun of length 410 mm, diameter 140 mm, and weight 20 kg was designed. An operating range of 2 to 50 keV was achieved, with electron beam currents up to 1 mA. A smaller more simplified model, for operation with rarefied gases, is also discussed. (R.V.J.)

**2212** ELECTRICAL CONDUCTIVITY MEASUREMENTS IN A FARADAY ACCELERATOR. Goldstein, Raymond; Richmond, J. Kenneth; Oates, Gordon C. (Boeing Scientific Research Labs., Seattle, Wash.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 4: 2043-5(Nov. 1966).

Electrical conductivity measurements carried out on a continuous-electrode Faraday accelerator operating at atmospheric pressure are analyzed. Continuous electrodes were used in an attempt to simplify the problem. Measurements within the uniform gas core were in good agreement with the currently accepted theory for seeded rare gas flows. The arc-heated argon was seeded in a plenum with NaK. (W.D.M.)

**2213** UPPER HYBRID RESONANT HEATING IN A SLIGHTLY IONIZED PLASMA. Takeda, Susumu; Masumi, Motoshi; Horio, Toshimasa (Nagoya Univ., Japan). J. Phys. Soc. Japan, 21: 1840(Sept. 1966).

The absorption of the heating microwave and the increase of the

light intensity were earlier detected at an upper hybrid resonance. This experiment was extended to measure the changes in the electron density and temperature of a helium plasma at a pressure of 1 mm Hg, when it is brought into an upper hybrid resonance state by a pulsed x-band microwave of high power. The plasma is preionized by a cw and rf discharge. (M.O.W.)

**2214** DEPENDENCE OF THE EXCITATION TEMPERATURE OF A CAPILLARY DISCHARGE PLASMA ON THE CAPILLARY RADIUS. Lee, Po (National Taiwan Univ., Taipei, China). Chin. J. Phys. (Taiwan), 4: 1-5(Apr. 1966).

Results of temperature measurements inside the plasma column of a capillary discharge used for a spectroscopic light source are presented. The plasma reached a local thermodynamic equilibrium within a microsecond. An empirical relation between the temperature and the capillary radius is given. (auth)

**2215** SPECTRUM OF THE INDUCTIVE PLASMA FLAME. Dunken, H.; Pforr, G. (Friedrich-Schiller-Univ., Jena, Ger.). Z. Chem., 6: 278(July 1966). (In German).

A flame burning in a winding of 32 mm dia of length 40 mm, lit by scattered charges arising from inductive warming of C in the Ar atmosphere, was examined. Technical Ar gave bands of neutral and ionized atoms as well as bands of $N_2$, $N_2^+$, OH, NO, CN, and NH, from impurities. In the inductive plasma flame only atomic lines of Ar with energies up to 14.68 eV were observed. There is a continuum in addition with max darkening between about 3600 to 4500 Å. Weak bands for OH and four CN bands appear in the region between 3100 Å and 3900 Å as well. The difference in the spectra is due to the difference in excitation temperatures; in the first flame, the electron temperature is about 13,500°K and the gas temperature 3000°K to 4000°K. In the inductive flame, the gas temperature is 16,400°K. Solids and liquids may be introduced into the inductive flame more easily than into the torch flame; representative darkenings of Fe are given in a table, obtained from the aerosol of a $10^{-3}$N $(NH_4)_2Fe(SO_4)_2$ solution. (BBB)

**2216** PERCENTAGE IONIZATION IN CROSSED-FIELD LABORATORY PLASMA SOURCES. Brown, I. G.; Cross, R. C.; James, B. W.; Watson-Munro, C. N. (Univ. of Sydney). Phys. Lett., 23: 451-2(Nov. 14, 1966).

Large-amplitude Alfvén waves were used to reionize decaying hydrogeneous laboratory plasmas, and Stark broadening was used to measure the reionized density. (auth)

**2217** COLLISION BROADENING OF ATOMIC SPECTRAL LINES IN PLASMAS. Palmer, Paul. New Haven, Yale Univ., 1966. 327p.

Thesis.

The theory of the collision broadening of atomic spectral lines was developed from the Fourier Integral Formula in a manner which makes no use of the impact or static approximations. The classical path approximation is made and it is assumed that the perturbations are scalarly additive and that collisions are adiabatic. The results are expressed in terms of repeated foldings of elementary shapes. A computer program for implementing the result is presented and explained. The program performs the Fourier integrations numerically, thus avoiding the impact and static approximations. The collision trajectories are found by Newton's Laws. A smooth attenuation of the contributions from large impact parameters is employed, rather than a cutoff at the Debye radius. Several results for the three components of the Cesium 10P-6S line are presented. (Dissertation Abstr.)

**2218** INSTRUMENTATION FOR HIGH SPEED PLASMA FLOW. Fuhs, A. E. AGARDograph 96. New York, Gordon and Breach Science Publishers, 1965. 192p.

The discussion principally considers electrodeless instruments which use magnetic or electromagnetic fields to probe the plasma. Electrostatic probes are briefly reviewed, and the features of different plasma flows, e.g., the sheath surrounding a re-entry vehicle, rocket exhaust, ballistic ranges and MHD generators, are related to the instrumentation theory and design. Instruments for determining both macroscopic and microscopic plasma properties are described in detail with liberal use of figures and illustrations, and regimes where different measuring devices are applicable are delineated. Also included are two useful tables, of MHD and plasma formula and constants and conversion factors. (M.O.W.)

## *Kinetics of Plasma*

*Refer also to abstract 2200.*

**2219** (AD-630611) THE NONLINEAR CONDUCTIVITY OF A WEAKLY IONIZED, NON-MAXWELLIAN MAGNETOPLASMA. Physical Sciences Research Papers. Haskell, Richard E.; Papa, Robert J. (Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.). Feb. 1966. 26p. (AFCRL-PSRP-191; AFCRL-66-81). CFSTI $2.60 cy, $0.50 mn.

The ac conductivity of a weakly ionized plasma can be calculated by making a spherical harmonic expansion of the electron velocity distribution function. This conductivity determines the propagation characteristics of rf waves in the plasma. If the plasma is immersed in a dc magnetic field, the isotropic part of the distribution function depends upon the polarization of the rf wave; that is, it depends upon how the electromagnetic energy is divided among the right and left circularly polarized modes and the longitudinal mode. When the magnetic field is reduced to zero, the function reduces to the form first derived by Margenau. A closed form expression for the function can be obtained for the case of a constant electron mean free path. A nonlinear conductivity tensor can be derived in which each component is a function of the polarization of the local rf field. Curves of the conductivity tensor components in the principal coordinate system as a function of the energy in the right and left circular modes are presented for propagation along the magnetic field. (auth)

**2220** (AD-630703) PLASMA-ELECTRODE PHENOMENA OF THE RAIL TYPE ACCELERATOR. Clingman, D. L.; Rosebrock, T. L. (General Motors Corp., Indianapolis, Ind. Allison Div.). Sept. 1961. Contract AF 49(638)-864. 36p. (EDR-2277; AFOSR-1964). CFSTI $3.60 cy, $0.50 mn.

Real discharge effects are considered for the rail type electromagnetic accelerator with special emphasis devoted to electrode phenomena. Net plasma motion is shown to be independent of arc motion, which may occur in any of three modes. Experimental evidence is cited in support of a discharge model composed of multiple conducting paths in parallel with the main arc. Spectrographic experiments are described in which electrode erosion is found to be virtually nonexistent under conditions of sustained arc motion. (auth)

**2221** (AD-632125) AN EQUATION FOR PHASE VELOCITIES IN A PARTIALLY IONIZED GAS. Curchack, H. D.; Harris, F. T. (Harry Diamond Labs., Washington, D. C.). Feb. 1966. 25p. (TR-1316; HDL-36500). CFSTI $1.10 cy, $0.50 mn.

Previous work was extended on a fully ionized gas by including the effects of neutral particles. Proper manipulation of the equations yields a homogeneous linear differential equation for the vector conduction current density. By choosing the conduction current density of the form e (iw(t-y/v)), the magnetic field in the x-y plane, and by setting the determinant of the coefficients in the homogeneous scalar conduction current density equations equal to zero, an expression is obtained relating many phase velocities to the properties of the plasma. The mathematical derivation of the determinant is given. (auth)

**2222** (CEA-R-2960) ONDES DANS LES PLASMAS INHOMOGENES EN GEOMETRIE CYLINDRIQUE. (Waves in Inhomogeneous Plasma of Cylindrical Geometry). Rebut, Paul-Henri (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). 1966. 71p. In French. (EUR-2725.f). Dep. mn.

Thesis. Submitted to Paris Univ., France.

The conductivity tensor of a hot and inhomogeneous plasma was calculated for a cylindrical geometry using Vlasov's equations. The method used consists in a perturbation method involving the first integrals of the unperturbed movement. The conductivity tensor will be particularly useful for dealing with stability problems. In the case of a cold plasma the wave equation giving the electric fields as a function of the radius is obtained. This equation shows the existence of resonant layers which lead to an absorption analogous to the Landau absorption in a hot plasma. (auth)

**2223** (CEA-R-3053) EXCITATION SIMULTANEE DES RESONANCES ELECTRONIQUE ET IONIQUE DANS UN PLASMA DANS UN CHAMP MAGNETIQUE STATIQUE, PRODUITE PAR UN CHAMP ELECTROMAGNETIQUE H. F. MODULE A UNE BASSE FREQUENCE. (Simultaneous Excitement of Electron and Ion Resonances in a Magnetoplasma by a High Frequency Electromagnetic Field Low Frequency Modulated). Zilli, Enrico (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). July 1966. 46p. (In French). Dep. mn.

A single-particle, collisionless, nonrelativistic theory is exposed, in which the possibility is shown of exciting electron and ion resonances in a magnetoplasma, by means of a high-frequency electromagnetic field, whose amplitude is low-frequency-modulated. Two solutions of this problem are given. The first one rests on the possibility of exciting the ion cyclotron resonance taking into account the low-frequency electromagnetic field, low-frequency-modulated. In the second solution the possibility of exciting the electron and ion resonances is considered in an electromagnetic field, whose magnetic component parallel to $\vec{B}_0$ is low-frequency-

modulated. The results are discussed in the field of a cylindrical waveguide driven in the $TE_{01}$ mode, $\vec{B}_0$ being parallel to the axis. (tr-auth)

**2224** (IPPJ-51) PROPAGATION OF ION ACOUSTIC SOLITARY WAVES OF SMALL AMPLITUDE. Washimi, Haruichi; Taniuti, Tosiya (Institute of Plasma Physics, Univ. of Nagoya (Japan)). Aug. 1966. 6p. Dep. mn.

It is shown that under certain approximations the basic system of equations governing the propagation of ion-acoustic waves can be reduced to the Kortweg-de Vries equation. (auth)

**2225** (MATT-441) NUMERICAL EXPERIMENTS IN PLASMA PHYSICS. Shanny, Ramy A.; Dawson, J. M.; Greene, J. M. (Princeton Univ., N. J. Plasma Physics Lab.). July 1966. Contract AT(30-1)-1238. 84p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A model of a plasma is constructed for numerical computations. The plasma represented by the model consists of electrons subjected to a one-dimensional self-consistent electric field, and to collisions with ions, which are infinitely heavy and uniformly distributed throughout the plasma. The model computes the exact motion of the electrons due to the electric field, and a Monte-Carlo technique is used to account for corrections in the trajectories due to encounters with ions. The model to its lower order is identical to the Fokker-Planck equation with a Lorentz gas collision term. Mathematical difficulty in the solution of the Fokker-Planck equation appears when studying inherently nonlinear effects, and when the effect of collisions is not negligible. Numerical solutions for several such problems were obtained using the model. The effect of collisions on Landau damping and on the growth of an instability caused by a hump in the tail of the velocity distribution was studied. The validity of the collision simulation of the model was checked by measuring the dc conductivity, and comparing the result with the Spitzer-Härm conductivity. (M.O.W.)

**2226** (N-66-22244) USE OF A COAXIAL GUN FOR PLASMA PROPULSION. Final Report. Lovberg, R. H.; Hayworth, B.; Gooding, T. (General Dynamics/Astronautics, San Diego, Calif. Space Science Lab.). May 15, 1962. Contract NAS5-1139. 93p. (NASA-CR-64213). CFSTI $3.00 cy, $0.75 mn.

An investigation was undertaken to determine whether the coaxial gun concept is feasible for plasma propulsion. The study dealt with two broad areas: the physics of the acceleration process in a coaxial gun, especially those phenomena which influence efficiency; and the engineering feasibility of the free gas flow high repetition rate mode of operation. Priority was given to physical measurements of plasma phenomena in the gun. The experiments conducted were done on a series of coaxial guns which successively incorporate parameter changes dictated by the experimental results. These are designated Mark I through Mark IV. Their characteristic parameters and experimental behavior are discussed and a description of their mechanical details is included in the appendix. The principal diagnostic tools used were magnetic and electric probes. The program demonstrated that plasma acceleration by $\vec{j} \times \vec{B}$ forces does not take place in snowplow fashion, but rather through momentum transfer from an ionizing current wave which moves through the plasma. (STAR)

**2227** (P-3188(RAND)) OBLIQUE WAVE PROPAGATION IN A COMPRESSIBLE GENERAL MAGNETOPLASMA. Unz, H. (RAND Corp., Santa Monica, Calif.). Aug. 1965. 24p.

The refractive index equation was derived for arbitrarily directed oblique waves in compressible general magnetoplasma with arbitrarily directed magnetostatic field. The q factor obeys a general sixth-order algebraic equation. Booker's quartic equation and other particular cases were discussed. The general result is checked by using tensor analysis methods and transformation of coordinates. (auth)

**2228** (TID-23318, pp 93-121) PLASMA PHYSICS. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

The purpose and principles of operation of an electromechanical device to feed experimental data automatically into a time-shared computer system are described. Attempts were made to excite sinusoidal plasma density perturbations at the cathode of a hollow-cathode discharge. The resulting diffusion waves were studied and gave data from which the effective diffusion coefficients of the highly ionized dense plasma may be determined. Calculations are presented of the performance of the optical system to be used in measurements of spectral-line profiles emitted by the hollow-cathode arc discharge. A Fabry-Perot etalon was used in the measurements. The computations were performed to investigate the application of the optical system to spatially resolved measurements of line profiles. Observations were made of the scattering of microwaves from electron density fluctuations in a plasma produced by an electron beam. A fused-quartz bubble window for far infrared radiation is described. The thin-walled bubble blown inward (convex toward the low-pressure region) is always under tension when subjected to the large pressure differential. (W.D.M.)

**2229** (TID-23318, pp 123-6) LOW-FREQUENCY OSCILLATIONS IN AN ELECTRON-CYCLOTRON RESONANCE DISCHARGE. Ingraham, J. C.; Novenski, A. E. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

An experiment was initiated to study the low-frequency plasma waves that are excited in a volume of plasma produced by microwave breakdown at the electron-cyclotron frequency. The experiment is described and preliminary results are quoted. The helium plasma was contained in a cylindrical quartz tube of 1.3-cm ID aligned parallel to a dc magnetic field. (W.D.M.)

**2230** (UCRL-17171) GASEOUS THERMAL ELECTRON REACTIONS. Young, Charles E. (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1966. Contract W-7405-eng-48. 98p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Thesis.

A microwave cavity resonance technique was used to study the rate of disappearance of gaseous electrons in the presence of molecules which can capture them to form negative ions. Electron concentrations of $10^7$ to $10^8$ per cc were produced by photoionization of a small amount of NO with a single pulse of 1216 or 1236 Å light from microwave discharge in hydrogen or krypton, respectively. Experimental conditions also involved the presence of 1 to 100 torr of inert gas, which permitted the electrons to reach quickly a Maxwellian energy distribution corresponding to 300°K, and reduced the diffusional loss of electrons. Under these conditions, electron attachment to $SF_6$, $C_7F_{14}$, and $C_3F_8$ was observed to correspond to a two body process with rate constants of $2.7 \times 10^{-7}$, $8.8 \times 10^{-8}$, and $8.8 \times 10^{-12}$ cc/molecule-sec, respectively. Attachment to $C_2F_4$ and $SiF_4$ appeared to be a three body process but estimation of rate constants was less accurate. The effectiveness of various inert gas molecules in producing three body attachment of electrons to NO was also investigated. For He, Ne, $N_2$, Ar, Kr, and Xe, measured three body rate constants were, respectively, $2.2 \times 10^{-32}$, $1.8 \times 10^{-32}$, $3.7 \times 10^{-32}$, $3.2 \times 10^{-32}$, $0.65 \times 10^{-32}$, and $10.3 \times 10^{-32}$ (cc/molecule)$^2$ sec$^{-1}$. (auth)

**2231** (UCRL-Trans-10065) SOME CHARACTERISTICS OF CASCADE PULSED PLASMA INJECTORS. Azizov, E. A.; Komel'kov, V. S.; Skvortsov, Yu. V.; Tereshchenko, V. N. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). Translated by T. Watt for Univ. of California, Lawrence Radiation Lab., Livermore, from report IAE-1015. 40p. Dep. mn. CFSTI $2.00 cy, $0.50 mn. JCL $3.60 fs, $1.40 mf.

The properties of plasma blobs in two-stage pulsed-electrode injectors were investigated. Different types of coaxial guns were used for the first stage where preliminary ionization and acceleration of the hydrogen plasma takes place. Ring electrodes were used for the second stage; a discharge arose across these, accompanied by constriction and acceleration of the plasma by currents carried away. It was established that: (1) thanks to the preliminary ionization and the absence of electrodes in the region of high current densities, the amount of impurities in the blobs was greatly decreased; (2) as a result of the processes taking place in the second stage, the velocity of the frontal blobs was increased, reaching $1.5 \times 10^8$ cm/sec, and an effective splitting of the blobs took place, into a frontal relatively clean and a trailing, contaminated part; (3) the acceleration of the plasma in the second stage occurred outside the electrodes and depended essentially on the polarity of these and on the slope and amplitude of the stage's currents; and (4) the effective action of the second stage takes place even in longitudinal magnetic fields. The highest velocity attained by the blobs in a field of 1.5 kOe was $7 \times 10^7$ cm/sec. The number of stages which may be used in a system is in principle unlimited. (auth)

**2232** APPLICABILITY OF LOCAL THERMODYNAMIC EQUILIBRIUM APPROXIMATION. Lagarkov, A. N. (Moscow Inst. of Power Engineering). Teplofiz. Vysok. Temp., 4: 305-13 (May-June 1966). (In Russian).

The nonequilibrium state induced in a plasma with variable kinetic temperature by the transfer of radiation within the plasma and its emission was investigated. Integral equations for electron concentration and excited atoms were developed. An analysis of these equations produced criteria applicable to the local electron concentration and atom excitation close to the equilibrate magnitude corresponding to the local kinetic temperatures. (tr-auth)

**2233** FUNCTION FOR ELECTRON DISTRIBUTION IN NONEQUILIBRIUM PLASMA ACCORDING TO THEIR VELOCITIES.

Ulyanov, K. N. (Lenin All-Union Electro-Technical Inst., USSR). Teplofiz. Vysok. Temp., 4: 314-23(May-June 1966). (In Russian).

A symmetric function for electron distribution was analyzed in the case in which electron distributions according to their velocity are controlled by electron–electron and inelastic interactions. Analytical solutions were derived in a form of a mixture of the Whittaker equations. The direct and inverse interactions are considered and coefficients of atom excitations and quenching during collisions with electrons were calculated. (R.V.J.)

**2234** ON EM-WAVE SELF-FOCUSING IN MAGNETOACTIVE PLASMA. Litvak, A. G. Izv. Vyssh. Ucheb. Zaved., Radiofiz., 9: 900-9(1966). (In Russian).

Phenomena of two-dimensional electromagnetic wave self-focusing in a magnetoactive plasma in the case of a transverse propagation were studied. The expression was derived for the tensor of a nonlinear permittivity of magnetoactive plasma. A qualitative investigation of the field equation system on a phase plane was carried out. The structure of an autolocalized field was found by numerical methods for some values of plasma parameters. It is shown that the field self-focusing is accompanied by increase of plasma concentration on the axis (by plasma waveguide formation) near the electron gyro-resonance ($\omega_H \approx \omega$). In some limiting cases (for a magnetic field value) the approximate solutions of field equations were obtained in an analytical form. (auth)

**2235** SOLUTIONS OF THE EQUATIONS FOR SPACE-CHARGE ELECTRON FLOW WITH A MAGNETIC FIELD AT THE CATHODE FOR BEAMS OF NON-UNIFORM CURRENT DENSITY. Mayo, B. J. (Electric and Musical Industries, Ltd., Hayes, Eng.). Int. J. Electron. (1), 20: 545-51(June 1966).

After a discussion of the space-charge equations, a solution is given from which the critical conditions are obtained for flows like Brillouin flow but with a magnetic field at the cathode. Results for confined flows are derived; it is shown that, compared with a beam of uniform current density, much more current can be put into a beam of given boundary voltage if the current density increases strongly with radius. Confined ribbon beams are also considered. (auth)

**2236** PROPAGATION OF ELECTROMAGNETIC WAVES ALONG AN ANNULAR PLASMA. Pinder, D. N.; Foulds, K. W. H. (Battersea Coll. of Tech., London). Int. J. Electron. (1), 20: 553-66(June 1966).

The characteristics of propagation for the lowest-order mode in a coaxial line partially filled with an annular plasma tube were investigated theoretically. The system supports two slow waves, and a fast wave which is a perturbed form of the TEM wave which would propagate if the coaxial line contained a single homogeneous dielectric. The fast wave cuts off at the plasma frequency. The effect of nonuniformity of the plasma annulus on the $\omega-\beta$ diagram was derived using approximate techniques. The experimental work was confined to the study of fast waves in the coaxial line and slow waves in the same structure but with the inner conductor removed. (auth)

**2237** DYNAMICS OF CURRENT SHEETS IN A COAXIAL ACCELERATOR. Naraghi, M. (Aria-Mehr Univ. of Tech., Tehran, Iran). Int. J. Electron. (1), 20: 503-15(June 1966).

The theory of electromagnetically driven shocks is applied to coaxial accelerators. By assigning different values of $\gamma$, the ratio of specific heats, the three models of snowplow, free particle, and shock can be reconciled. This theory is compared with the experimental measurement of the current sheet velocity in a coaxial accelerator with an aspect ratio two, and uniform gas distribution. Only at early times does the snowplow model give an adequate explanation of the current sheet velocity. At times later than 2 $\mu$sec, the sheet moves with a greater speed than the values calculated from a snowplow model. (auth)

**2238** RESONANCE ABSORPTION OF ELECTROMAGNETIC POWER BY WEAKLY IONIZED GAS. Stoytchev, T.; Zhelyazkov, I. (Sofia Univ.). Int. J. Electron. (1), 20: 517-24(June 1966).

There was observed and investigated the resonance absorption of electromagnetic power in the frequency band 1 to 10 Mc/s by weakly ionized plasma, produced in a cylindrical discharge tube. It is established that the Q factor of a resonant circuit, whose capacitor is a split cylinder enveloping the discharge tube, depends on the discharge current and displays resonance properties. Parallel with the increase of the frequency of the applied field the resonances move up to higher currents and they become less sharp. The experiments are made with helium, neon, argon and krypton at the pressure of 0.05 to 1 torr. For heavier gases the resonances are obtained with weaker currents. The dependence of the resonances on the pressure is slightly expressed. To explain this phenomenon it is supposed that the ions and the collisions between them and the neutral atoms play the fundamental role. In the presence of an alternating electrical field the ions of the plasma begin forcibly to oscillate, while the availability of a quasi-elastic force, resulting from the separation of the electrical charges, and damping force, due to the collisions, brings about resonance dependence of the discharge current on the field frequency. The accepted model satisfactorily explains the obtained experimental data. (auth)

**2239** LINE PROFILE IN THE ONE-ELECTRON APPROXIMATION. Cooper, J. (Joint Inst. for Lab. Astrophysics, Boulder, Colo.). Phys. Rev. Lett., 17: 991-5(Nov. 7, 1966).

The shape of a pressure-broadened line in the classical approximation is $I(\omega) = 1/\pi\ \mathrm{Re}\mathrm{Tr}\int_0^\infty e^{-i\omega s}\,(Z(0)Z(s)\rho_A)_{AV}ds$, where $Z(s)$ and $\rho_A$ are the dipole moment and density matrix operators. In an earlier paper by Griem this expression was used to evaluate the electron-impact broadening of isolated ion lines. It is shown here that some terms used by Griem should not be included, and that this one-electron approximation should give results identical with the impact approximation. (M.O.W.)

**2240** PROPAGATION OF ION ACOUSTIC SOLITARY WAVES OF SMALL AMPLITUDE. Washimi, Haruichi; Taniuti, Tosiya (Nagoya Univ., Japan). Phys. Rev. Lett., 17: 996-8(Nov. 7, 1966).

The one-dimensional long-time asymptotic behavior of ion–acoustic waves of small but finite amplitude is shown to be described by the Kortweg–deVries equation in the same sense as was given by Gardner and Morikawa for a hydromagnetic wave in a cold plasma. (M.O.W.)

**2241** PULSE STIMULATED RADIATION FROM A PLASMA INVOLVING THE SECOND HARMONIC OF THE GYROFREQUENCY. Kegel, W. H. (California Inst. of Tech., Pasadena). Phys. Lett., 23: 317-18(Oct. 31, 1966).

If a plasma is excited by two short pulses at the gyrofrequency and its second harmonic, respectively, with a time separation $\tau$, a radiation maximum is predicted to occur at the gyrofrequency a time $\tau$ after the second pulse. (auth)

**2242** ELECTRONIC PROPERTIES OF FINE METALLIC PARTICLES. II. PLASMA RESONANCE ABSORPTION. Kawabata, Arisato; Kubo, Ryogo (Tokyo Univ.). J. Phys. Soc. Japan, 21: 1765-72(Sept. 1966).

Fine metallic particles exhibit a peak of optical absorption around the frequency of the plasma mode. The absorption is broadening by coupling of the plasma oscillation with the individual electronic states which are quantized in discrete levels. Thus the broadening should not be interpreted as the resistance of free electrons scattered at the surfaces of particles. The quantum-mechanical treatment is described on the basis of the linear response theory. Existent experimental data are discussed briefly. (auth)

**2243** EXCITATION OF ION WAVES IN A WEAKLY IONIZED CURRENT-CARRYING PLASMA. Sato, Noriyoshi; Hatta, Yoshisuke (Tohoku Univ., Sendai). J. Phys. Soc. Japan, 21: 1801-3 (Sept. 1966).

Ion waves in a weakly ionized plasma under an electric and magnetic field is discussed on the basis of the two-fluid model. The Hall current is shown to make ion waves unstable with ease in a weakly ionized plasma. The unstable region and the growth rate are obtained for various ratios of the electron drift velocity to the electron thermal velocity. (auth)

**2244** INTERNAL PLASMA RESONANCE OF POSITIVE COLUMN NEAR ELECTRON CYCLOTRON HARMONIC FREQUENCIES. Tanaka, Shigetoshi (Nagoya Univ., Japan). J. Phys. Soc. Japan, 21: 1804-16(Sept. 1966).

A series of subsidiary resonance peaks observed near the electron cyclotron harmonics is studied by the measurements of microwave radiation from a positive column in a magnetic field. When the positive column is irradiated by an external microwave, an intensity of subsidiary resonance peaks increases extremely and also a number of their peaks increases. Further, their dispersion curves displace toward a higher magnetic field and toward a higher electron density, compared with those when there is no external microwave power. The experimentally observed behavior of these peaks can be explained that a series of subsidiary resonance peaks is resulted from the internal plasma resonance due to the standing plasma waves within the propagating region of the plasma column. (auth)

**2245** EXPERIMENT ON MICROWAVE ABSORPTION BY MAGNETOPLASMA. Kubo, Hiroshi (Kyoto Univ.). J. Phys. Soc. Japan, 21: 1834(Sept. 1966).

The microwave absorption in a plasma column was investigated and a structure was found which consists of several resonance-like lines at the magnetic field slightly higher than the electron cyclotron resonance. Similar but weak lines were observed on the microwave emission from the same plasma. The results are described. (M.O.W.)

**2246** HIGHER HARMONICS OF THE ANOMALOUS CYCLOTRON EMISSION FROM PARTIALLY IONIZED PLASMA. Idehara, Toshitaka; Abe, Haruhiko; Terumichi, Yasushi (Kyoto Univ.). J. Phys. Soc. Japan, 21: 1835(Sept. 1966).

The uhf-band emission from partially ionized gases having the large Ramsauer effect was investigated, and the anomalous cyclotron harmonics, up to the 4th, were detected. The results are described for a Xe plasma. (M.O.W.)

**2247** THE EFFECTS OF THERMAL MOTION OF CHARGE CARRIERS UPON THE VELOCITY OF ALFVEN WAVES PROPAGATING ACROSS A MAGNETIC FIELD IN DEGENERATE ELECTRON-HOLE PLASMA. Yokota, Isaaki (Niigata Univ., Japan). J. Phys. Soc. Japan, 21: 1851-2(Sept. 1966).

A brief analysis is presented which uses the dispersion equation. (M.O.W.)

**2248** FAST-WAVE PROPAGATION IN PLASMA-FILLED WAVEGUIDES. Bevc, Vladislav (Aerospace Corp., El Segundo, Calif.); Everhart, Thomas E. J. Electron. Contr., 13: 185-212 (Sept. 1962).

In the analysis of the waves which propagate in a waveguide completely or partially filled with a stationary plasma column or an electron beam drifting with a uniform velocity and collimated with a magnetic field of finite magnitude, it is necessary to include the effects of the rotation of the electric field to treat the waves which have phase velocities comparable to or greater than the velocity of light. Certain features of perturbed waveguide modes and cyclotron modes become apparent only when the dynamic nature of the electric field is recognized in the analysis. These features are the influence of cyclotron frequency and the polarization of waves on the propagation characteristics. The cyclotron modes are found to be purely transverse electric at cutoff, gradually changing in character along their propagation curves through hybrid to purely transverse magnetic modes at cyclotron resonance. A classification of modes of propagation is proposed, and formulae for cutoff frequencies as functions of the cyclotron frequency as well as some representative Brillouin diagrams are given. Equations for neutralized electron beams are obtained when the Lorentz transformation is applied to the equations for stationary plasmas. The solutions for stationary plasmas can be transformed directly into the solutions for neutralized electron beams. (BBB)

**2249** PLASMA TURBULENCE EVALUATION ACCORDING TO ELECTROMAGNETIC RADIATION AND RAMAN SCATTERING IN MICROWAVE BAND. Demidov, B. A.; Fanchenko, S. D. At. Energ. (USSR), 20: 516-18(June 1966). (In Russian).

The degree of turbulence of a plasma may be estimated from the Raman scattering of electromagnetic waves on electron oscillations. These studies were continued in experiments on a toroidal plasma confined by a 3.5-kg (kilogauss) magnetic field, in which a 5-MHz electric field was created, exceeding slightly the critical Dreisser field. This generates a 50 to 70 A/cm$^2$ current in the plasma, causing plasma oscillations and heating up the electrons. The phenomenon is accompanied by strong x and uhf radiation of the plasma. It was attempted to determine the plasma oscillation density W by comparing the intensity of the uhf radiation $P_t$ at the double plasma frequency $2\omega_{ep}$ with the intensity $P_s$ of the signal corresponding to the violet range of the Raman scattering on plasma oscillations of the generated electromagnetic waves. A formula was derived for determining the degree of turbulence. Assuming that the electron temperature of the plasma $T_e = 100$ eV, the degree of turbulence was calculated at about $k_D/6$, whereby $k_D$ designates the Debye wave vector. This result is in fair agreement with previous findings. (TTT)

**2250** A TURBULENCE THEORY OF THE LONGITUDINAL WAVES IN ELECTRON PLASMAS. Sasakura, Yutaka (Japan Atomic Energy Research Inst., Tokyo). Progr. Theoret. Phys. (Kyoto), 36: 413-15(Aug. 1966).

The turbulence theory of an incompressible fluid is extended to the case of a compressible plasma and the equipartition law of kinetic and electric energies among all wave numbers is derived simply for a cold plasma. The effects of temperature are discussed briefly. (L.B.S.)

**2251** STATISTICAL MECHANICS OF TURBULENT PLASMAS. I. DIAGRAM FORMULATION FOR THE KLIMONTOVICH EQUATION. Nishikawa, Kyoji (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 36: 193-223(Aug. 1966).

A statistical mechanical theory for the investigation of the effects of nonlinear fluctuations in a plasma is developed. The starting equation is the Klimontovich equation for the "fine-grained" single-particle distribution function and the quantities of interest are the space–time correlation functions, which are certain ensemble averages of the products of these fine-grained distribution functions. The ensemble average is specified in essentially the same way as in Prigogine's theory of nonequilibrium statistical mechanics for a spatially homogeneous system. The nonlinear terms in the Klimontovich equation are treated as a perturbation. Various types of secular terms are found in the perturbational solution. A diagram technique is introduced to classify various terms in the perturbation series. It is then found that the secular terms of importance can be attributed to a certain class of diagrams (the diagonal part) and that the latter can be summed up so as to yield a well-defined time-dependence of the physical quantities. The total contribution of the diagrams is then expanded in an infinite series in terms of the contributions of the diagonal parts and appropriately defined vertex parts. The general results obtained are illustrated using the quasilinear approximation. Although the main discussion is restricted to an electron plasma in zero external field, it is shown that little modification is needed in order to generalize the results of an electron-ion plasma and to a plasma in the presence of a uniform external magnetic field. (auth)

**2252** WAVE PROPAGATION IN A RAREFIED PLASMA WITH FINITE LARMOR RADIUS. Bajaj, N. K. (Univ. of Delhi); Tandon, J. N. Z. Phys., 197: 159-71(1966).

Wave propagation in a rarefied two-component plasma immersed in a uniform constant magnetic field was discussed wherein the plasma pressure is assumed to be anisotropic owing to finite Larmor radius effect. It is shown that, for propagation along the external magnetic field, there exist two modes of wave propagation, namely, the gravitational mode and the hydromagnetic mode. The former is found to be independent of the magnetic field and hence of the Larmor radius, while the latter is appreciably influenced by the finite Larmor radius. On the other hand, for transverse propagation, there are three modes of wave propagation, viz., the ion–sound mode, the electron–sound mode, and the electromagnetic mode. It is shown that only the low-frequency ion–sound mode is affected by the finite Larmor radius. (auth)

**2253** THERMALIZATION OF PLASMA ELECTRONS. Bottoms, P. J.; Eisner, M. (Texas A and M Univ., College Station). Phys. Rev. Lett., 17: 902-3(Oct. 24, 1966).

Measurements are reported on the rate of thermalization of a highly ionized plasma with initially hot ions and cold electrons. (M.O.W.)

**2254** PARAMETRIC COUPLING BETWEEN ELECTRON-PLASMA AND ION-ACOUSTIC OSCILLATIONS. Stern, R. A.; Tzoar, N. (Bell Telephone Labs., Whippany, N. J.). Phys. Rev. Lett., 17: 903-5(Oct. 24, 1966).

The simultaneous excitation of electron-plasma and ion-acoustic oscillations by means of a single electromagnetic wave at $\omega \cong \omega_p$ was observed experimentally and analyzed theoretically, with consistent results. (auth)

**2255** HIGHER ORDER BEHAVIOR IN THE BOLTZMANN EXPANSION OF THE BOGOLIUBOV-BORN-GREEN-KIRKWOOD-YVON HIERARCHY. Goldman, R. (Univ. of Maryland, College Park). Phys. Rev. Lett., 17: 910-12(Oct. 24, 1966).

An investigation was made to indicate the form of equations governing divergent many-body behavior within the spatially homogeneous BBGKY hierarchy in the Boltzmann approximation for cut-off potentials, the nondivergent nature of the solutions which results from a linearization around a Maxwellian velocity distribution, and the strong analogy between this behavior and the structure of the BBGKY hierarchy in the plasma approximation. (M.O.W.)

**2256** SOME RESULTS CONCERNING A LOW-INDUCTANCE 50-kV SPARK GAP. Bensussan, A. Ann. Radioelec., 21: 250-65 (July 1966). (In French).

The development is described of a low inductance 50-kV spark gap. The properties required of a spark-gap: high voltage handling capacity, low inductance, and least possible jitter are discussed. The solution adopted is then described, as well as the general ideas which have led to the development of the equipment tried experimentally. On this occasion a description is given of a new type of plasma gun derived from the Bostick gun. The experimental results and an attempt at their interpretation, more particularly concerning the spark-gap's triggering time and its jitter, are given. (auth)

**2257** STUDY OF COHERENT INTERACTION OF TWO WAVES IN A PLASMA. APPLICATION TO RADIOCOMMUNICATION OVER LONG DISTANCES. Blachier, B.; Bouchet, P. Ann. Radioelec., 21: 171-94(July 1966). (In French).

The interaction of two waves of different frequencies in a plasma is examined in order to bring out the possibilities of generating a new wave at a frequency which is a harmonic of the first two. After the theoretical examination of this interaction a description

is given of an application for radiocommunication over long distances, interaction taking place in the F ionospheric layer. (auth)

**2258** ENERGY DISTRIBUTION FUNCTION IN POSITIVE COLUMNS. Pfau, Sigismund; Rutscher, Alfred (Ernst-Moritz-Arndt-Univ., Greifswald, Ger.). Beitr. Plasmaphys., 6: 205-9 (1966). (In German).

The energy distribution function experimentally obtained by means of the Druyvesteyn analysis of probe measurements in the positive column of a weak-current neon discharge is compared with theoretical distribution functions. The Maxwellian distribution used here proves to be unsuitable. The Druyvesteyn distribution represents a better approximation. (tr-auth)

**2259** ON THE DIFFUSION THEORY OF HOMOGENEOUS PLASMA COLUMNS WITH A DRUYVESTEYN DISTRIBUTION OF ELECTRON ENERGIES. Rutscher, Alfred (Ernst-Moritz-Arndt-Univ., Greifswald, Ger.). Beitr. Plasmaphys., 6: 195-204(1966). (In German).

On the basis of the Schottky diffusion theory, the characteristic quantities of the homogeneous positive column in neon were calculated using a Druyvesteyn distribution of electron energies and were compared with those obtained with a Maxwellian distribution. From the extension of the theory, and under simultaneous consideration of an ionization stage and a deviation from quasineutrality, the experimental characteristics of the column can be interpreted satisfactorily with a Druyvesteyn distribution in the region of small current intensities. (tr-auth)

**2260** ON THE REVERSIBLE NATURE OF THE VLASOV EQUATION AND ITS SOLUTION. Leven, Ronald (Univ., Greifswald, Ger.). Beitr. Plasmaphys., 6: 165-73(1966). (In German).

It is shown in the nonlinear approximation for the solution of the Vlasov equation, which describes the thermalization of an electron beam in plasma, and the so-called Landau damping, that the entropy remains constant. This means that the condition for the Vlasov equation to be reversible in relation to time reversal is actually fulfilled by the approximate solution used for the description, and that similar processes in a plasma, which can be described by the Vlasov equation are reversible in nature. (tr-auth)

**2261** MASS-SPECTROMETRIC INVESTIGATIONS ON THE POSITIVE COLUMN OF NITROGEN GLOW DISCHARGES. Schmidt, Martin (Deutsche Akademie der Wissenschaften, Berlin). Beitr. Plasmaphys., 6: 147-63(1966). (In German).

A description is given of a mass-spectrometric investigation of the charge carriers emerging from a small opening in the tube wall in the region of the positive column of a nitrogen low-pressure glow discharge at pressures of 0.75, 1.5, 2, and 3 torr and in the current region of 10 to 90 m amp. The positive ions $N^+$, $N_2^+$, $N_3^+$, as well as $NH_4^+$ and $H^+$ could be established. Only electrons could be found as negative charge carriers. Moreover, with gradient values and combined current intensities, electron temperatures could be determined. From the ion-current relations, electron temperatures, gradient values, and information from the literature on the drift velocities of the electrons and mobility of the ions of the ambipolar wall, the current density was calculated for 0.75, 1.5, and 2 torr. The measured electron current density is in close agreement with the calculated value. From the ion-current relations the concentrations of the specific types of ions were determined as functions of the discharge current. On the basis of the present measurement and the different interpretations by Saporoschenko and Dreeskamp, the $N_3^+$ ion formation is discussed. (tr-auth)

**2262** THERMODYNAMIC PROPERTIES OF THE ALKALI METALS CONSIDERED AS DILUTE PLASMAS. Milligan, John H. Jr. Lafayette, Ind., Purdue Univ., 1965. 251p.

Thesis.

Problems of calculating the thermodynamic and transport properties of gases using relations obtained in statistical mechanics for temperatures and pressures such that simultaneous chemical reactions and excited particle states must be considered are studied. Application of the theory to calculation of the properties of the inert gases and alkali-metal vapors is reviewed. Comments are made concerning the relative merits of data available in the literature. Expressions for the thermodynamic properties and equation of state of an ionizing gas obeying the Debye–Hückel solution theory were derived, including contributions resulting from termination of the atomic and ionic internal partition functions which have not been considered previously. The enthalpy, entropy, volume, composition and constant pressure heat capacity were calculated for lithium, sodium, potassium, rubidium, and cesium. A new thermodynamic diagram, believed to be more convenient than the conventional Mollier diagram for the presentation of thermodynamic data for chemically reacting gases, was developed. (Dissertation Abstr.)

**2263** AN EXPERIMENTAL STUDY OF THE INTERACTION BETWEEN A CONSTANT-VELOCITY TRAVELING-WAVE MAGNETIC FIELD AND A PLASMA IN AN ANNULAR CROSS SECTION CHANNEL. Ellson, Robert A. Rochester, N. Y., Univ. of Rochester, 1966. 141 p.

Thesis.

The interaction between a constant velocity traveling wave magnetic field and a plasma was studied for an annular cross section channel. Because of the relatively low operating frequency, 20 kc, a low-reluctance core was used to shape the magnetic field lines crossing the annulus; a substantially radial magnetic field, which exceeded the small axial component by at least a factor of 5, was generated. The resulting amplitude of the magnetic field intensity was 164 gauss. Electric fields associated with the coils cause an electrodeless discharge in the annulus. As the plasma conductivity increases, intense ring currents form. These plasma currents, interacting with the applied field, result in an electromagnetic body force ($F_x = J_\theta \times B_r$) which accelerates the plasma in the axial direction. Experimental data presented indicate that the electromagnetic body force effectively accelerates the plasma contained in the annulus; that more than 2 kw are transferred to the plasma; and that the presence of a radial electric field accounts for the high energy losses. Results show that this device may be an excellent accelerator for a nonequilibrium plasma provided the radial electric field is eliminated and techniques are developed to sustain the ring discharge below the present operating pressure of 100 to 300 $\mu$ Hg. (Dissertation Abstr.)

**2264** PROPAGATION OF WAVES IN A PLASMA-FILLED GUIDE IN PRESENCE OF A MAGNETIC FIELD. Camus, M.; le Mezec, J. (Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux, France). pp 323-47 of Electromagnetic Theory and Antennas, Proceedings of a Symposium. Part I. New York, Macmillan, 1963. (In French).

Wave propagation in a circular guide with the magnetic field along the axis of the guide was studied. The equation for dispersion of a guide completely filled with plasma is obtained. The cutoff frequencies for the modes of revolution in the filled guide are examined; variations of frequencies with dimensional changes in the guide are found, and the relation between the cutoff frequencies and the propagation of plane waves is obtained. The characteristics of slow waves in a circular guide and of waves of velocity approaching that of light in vacuo are discussed. The general form of the dispersion curves is discussed at length, and data obtained for ratios of $\omega_{01}$ to $\omega_p$ of 0.45 to 2.34 are illustrated graphically, for cases in which $\omega_c/\omega_p = 2$. (BBB)

## *Production of Plasma*

*Refer also to abstract 2216.*

**2265** THEORY OF HIGH-FREQUENCY HIGH-PRESSURE VORTEX DISCHARGE. Soshnikov, V. N.; Trekhov, E. S. (Moscow Inst. of Engineering Physics). Teplofiz. Vysok. Temp., 4: 324-7(May-June 1966). (In Russian).

Relations previously developed were used for calculating parameters of stationary high-frequency vortex discharge in the air at 1-atm pressure, 5-Mc field frequency, and 10,000°K temperature in the center. The low frequency, $f \approx 1$ Mc, is resolved by a simplified system of equations. Tabulated data and graphs are correlated with results previously obtained for the 50-Mc frequencies. The results correspond to the data calculated for argon. (R.V.J.)

**2266** GEOMETRY OF ELECTRODELESS DISCHARGE INDUCTED INTO INERT GASES. Rovinskii, R. E.; Belousova, L. E.; Gruzdev, V. A. Teplofiz. Vysok. Temp., 4: 328-35(May-June 1966). (In Russian).

Geometries of annular electrodeless discharges in argon and xenon at 12 Mc were studied as functions of pressure of $10^{-2}$ to 760 mm Hg, power at 2 to 14 kV, type of container wall cooling (air or water), and of the discharge dimensions (80 and 100 mm). Three pressure areas were found, each having specific characteristics related to the mechanisms of their formation. At high pressures (above ~250 mm Hg) the combination of experimental factors indicate the high importance of thermal conductivity in the process of plasma separation from the container walls and formation of induction discharge boundaries. (tr-auth)

**2267** STUDY OF A CONICAL ELECTRODE PLASMA GUN. Hirano, Keiichi; Ito, Hiroshi (Osaka Univ.). J. Phys. Soc. Japan, 21: 1787-1801(Sept. 1966).

Production of plasma by a conical electrode plasma gun and its behavior were studied by systematically changing the gas loading. The gun employs a low inductance power supply (total inductance: 80 nH) and pulsive admission of gas into vacuum. The instantaneous gas loading given by a fast-acting valve can be understood by the "valve chart" in which the average pressure $\bar{p}$ and the gas ex-

pansion delay time t are introduced as the most essential parameters. When t is small (t = 180 $\mu$ sec), the speed of ejected plasma is much larger than the pinching speed of the current shell inside the gun. This mechanism can be ascribed to the Munroe effect. The observed average energy of $D^+$ ions were beyond 2 keV; a considerable amount of more energetic impurity ions were found. (auth)

**2268** SPATIAL INHOMOGENEITIES IN THE PULSED GLOW DISCHARGE. Pond, D. R.; Garscadden, A. (Aerospace Research Labs., Wright-Patterson AFB, Ohio). J. Opt. Soc. Amer., 56: 1565-7(Nov. 1966).

Image-converter measurements of a pulsed mercury-vapor argon discharge illustrate the spatial characteristics of the initial discharge breakdown at currents below and above the Pupp limit. It is shown that striations, with lifetimes greater than 5 msec are created in the pulsed discharge at currents approximately twice the Pupp limit. Rather complex spatial structures are found in the initiation of the discharge if it is pulsed at repetition rates which do not permit complete de-ionization between successive pulses. The results suggest caution and further experiments in the interpretation of structure in the afterglow emission of pulsed glow discharges. (auth)

**2269** CONSTRICTED DISCHARGE COLUMN IN RARE GASES AT NORMAL PRESSURE. Wojaczek, Karl (Inst. of Physics and Technology, Berlin). Beitr. Plasmaphys., 6: 211-25(1966). (In German).

In stationary discharge columns the ionization rates at small ionization values with regard to the velocity distribution of the electrons depends strongly on the electron concentration. This dependency in rare gases at average pressures leads to a contraction of the discharge column. In the present work this effect is calculated by means of a simplified model. In particular, the radial distributions of the charge carriers were determined under different conditions. With the known collision cross section the macroscopic characteristic data for the positive column are obtained. The results can be formulated in the form of a similarity law. For the special case of argon, values for the electron temperature, field strength, and column contraction are given, in relation to the external discharge parameters. (tr-auth)

**2270** HEAT FLUX MEASUREMENTS IN A LONG ARC-PLASMA BEAM. Dreusicke, Manfred; Neumann, Werner (Physics and Technology Institut, Berlin). Beitr. Plasmaphys., 6: 175-93(1966). (In German).

The heat flux density q(r) transferred from a relatively wide and long arc-produced plasma beam (diameter of the discharge opening 2.5 cm, beam velocity $10^4$ cm/s) to a perpendicular conducting cold plate was measured and compared with the undisturbed enthalpy flux density of the plasma beams. These were determined over the radial temperature and velocity profile of the plasma beams. Thereby a strong broadening of the q(r) profile was shown compared with the f(r) profile at maximum reduction, from 3.8 kW/cm$^2$ to 90 W/cm$^2$, consistent with the formation of a plasma sheet in front of the conducting plate. The total heat conduction transferred with 1.7 kW amounted to only 32% of the total plasma beam conduction of 5.4 kW or 17% of the total arc conduction of 9.75 kW. In addition to these investigations in regard to applications of plasma beams to material melting, observations on the structure of the plasma beams and the arc column are reported. The arc column shows a spiral, whose origin has been investigated by Witkowski. This spiral produces an arc rotation and a spiral structure of the plasma beam. A light–dark structure of the plasma beams, which are associated with the motion of the anode patterns, was also observed. (tr-auth)

**2271** ELECTRODE CURRENT SATURATION IN MHD DUCTS. Armstrong, J. F.; George, D. W.; Messerle, H. K. (Univ. of Sydney). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 4: 2061-2(Nov. 1966).

Very few MHD experiments on the electric conductivity of seeded gases have allowed for the detailed effects of an electrode–plasma interface on the conduction process. Electrical, as well as thermal, sheaths on the electrodes restrict the free exchange of charges and introduce severe saturation effects. Experimental data are presented, indicating the general dependence of the saturation effect on electrode surface temperature, as well as bulk gas temperature. The experiments were carried out for applied, instead of induced, current flow and in the absence of a magnetic field. (W.D.M.)

**2272** STUDIES OF HIGHLY RADIATIVE PLASMAS USING THE WALL-STABILIZED PULSED ARC DISCHARGE. Church, Charles H.; Schlecht, Richard G.; Liberman, Irving; Swanson, Bruce W. (Westinghouse Research Labs., Pittsburgh). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 4: 1947-53(Nov. 1966).

Plasmas with pressures exceeding 1 atm and power densities to 300,000 W/cm$^3$ were created in a confined pulsed arc discharge in xenon. Theoretical models for the arc were studied for the cases for which a major portion of the input power is radiated in the optically thin spectral regions using a homogeneous temperature model. Because the optically thick radiation and/or thermal conduction are dominant, techniques for solving the integral differential power balance equation are being developed. The discharges to create the plasma have typically a 500-$\mu$sec duration with current densities ranging above 4000 amp/cm$^2$. Measurements were made of the wavelength and radial distribution of the spectral radiance, the current, and the voltage input. Using these values and the homogeneous temperature models, new values were determined for the spectral absorptivity of the continuum, and the electrical conductivity as a function of temperature. (auth)

## *Stability of Plasma*

**2273** (ORO-3405-9) INVESTIGATION OF UNIVERSAL PLASMA INSTABILITIES. Quarterly Report No. 4, June 1–August 31, 1966. Lashinsky, H. (Maryland Univ., College Park, Inst. for Fluid Dynamics and Applied Mathematics). Sept. 1, 1966. Contract AT(40-1)-3405. 4p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A brief outline is given on the research developments during this period. The developments concern various aspects of the experimental apparatus. (M.O.W.)

**2274** STABILITY IN DENSE PLASMA JETS. Messerle, H. K. (Univ. of Sydney). Brit. J. Appl. Phys., 17: 1461-71 (Nov. 1966).

The stability of dense plasma jets flowing into a transverse magnetic field is investigated. It is shown that longitudinal magnetoacoustic waves traveling along the jet can become unstable due to the perturbation of the electrical body force and coupling energy when electromechanical interaction takes place. Stability limits are established and expressed in terms of the relative plasma velocity $u_0 - u_e$, where $u_0$ is the jet velocity and $u_e$ a reference velocity for which no interaction takes place. The effect on stability of conductivity and Hall factor perturbation as a function of temperature and pressure are investigated allowing for electrical boundary conditions. For optimum energy transfer the electrical boundary conditions must be matched to the plasma, and it is shown that stability conditions improve when allowing for an external resistive load. (auth)

**2275** INSTABILITIES OF SEMICONDUCTOR PLASMAS IN CROSSED ELECTRIC AND MAGNETIC FIELDS. Suzuki, Toshimasa (Nippon Tel. and Tel. Public Corp., Tokyo). J. Phys. Soc. Jap., 21: 2002-12(Oct. 1966).

It is shown that in a slab of a semiconductor plasma subject to crossed electric and magnetic fields, a gradient in carrier density perpendicular to the magnetic field can cause a plasma density wave instability. General forms of the carrier density distribution and the dispersion relation are derived. Two types of instabilities, each of which has its equivalent in helical instability, are discussed, i.e., one caused by a density gradient which is established by the Lorentz force, and the other by a gradient due to the unsymmetry of the surface recombination velocities. Critical electric and magnetic fields for the onset of instability agree qualitatively with those observed in current oscillations in germanium under the same field configuration, especially for low magnetic fields. Possibility of applying the theory to the explanation of the oscillations in indium antimonide is indicated. (auth)

**2276** INTERACTION BETWEEN PLASMA OSCILLATION AND RADIATION FIELD. III. NONLINEAR COUPLING PROCESSES. Matsuura, Kenya (Electrotechnical Lab., Tokyo). J. Phys. Soc. Jap., 21: 2013-22(Oct. 1966).

Three-wave interaction Hamiltonians which describe the nonlinear couplings of plasma oscillation with electromagnetic field are derived by Bohm–Pines' method. These interactions cause nonlinear radiation from plasma oscillation and nonlinear resonant scattering of electromagnetic waves by plasma oscillation. The equations describing these phenomena are obtained to applying a quantum statistical treatment to the interaction Hamiltonians, and the characteristic features of the phenomena are discussed. (auth)

**2277** INVESTIGATION OF THE ZERO FREQUENCY HARRIS INSTABILITIES IN AN ELECTRON PLASMA. Brambilla, M. (CEN, Saclay, France). Phys. Lett., 23: 334-5(Oct. 31, 1966).

The dispersion relation for the electrostatic zero-frequency instabilities of a uniform plasma of monoenergetic electrons in a magnetic field is investigated, and numerical values of the growth rate are obtained. The limit of large wavelengths and the effects of a velocity spread are also examined, and rather severe conditions for the upset of instability are found. (auth)

**2278** MINIMUM-B RESISTANT LOW-FREQUENCY PLASMA INSTABILITIES. Wimmel, H. K.; Saison, R. (Institut fuer Plas-

maphysik, Garching, Ger.). Phys. Lett., 23: 449-50(Nov. 14, 1966).

If, in a collisionless, Taylor minimum-B configuration, the ion $v_\perp$ distribution is sufficiently nonmonotonic and $\omega_{pi} > 5\Omega_i$, then unstable electrostatic drift waves occur, with $|\mathrm{Re}\ \omega| \sim |k_\perp v_B| \ll |\mathrm{Im}\ \omega| \ll \Omega_i$, $k_\perp R_i \approx \pi$, $|k_\parallel R_i| \ll (m_e/5m_i)^{1/2}$. (auth)

**2279** INSTABILITY OF A BEAM-GENERATED PLASMA IN A UNIFORM MAGNETIC FIELD. Simpson, James Emmett. Stanford, Calif., Stanford Univ., 1966. 114p.

Thesis.

When an electron beam passes through a gas, a plasma is formed by ionization of the gas atoms. An investigation was made to study this instability, to identify the cause, and to determine under what conditions the interactions of the beam and plasma might be used for amplification of microwaves. The work was both theoretical and experimental. A cold-beam–cold-plasma model was analyzed and numerical values were computed for wave propagation and growth. The nature of a beam-generated plasma was studied experimentally. Wave propagation on the plasma column was observed using a slotted-line technique and gain was observed between two cavities spaced along the column. The theory shows that growing waves could be produced at low frequencies as a result of coupling of the beam to a forward wave on the plasma column or oscillations could occur at a higher frequency as a result of the coupling of the beam to a backward wave of the plasma which exists above the cyclotron frequency. It is concluded that the oscillations are the result of the forward-wave interaction with the beam, in combination with the reflection-feedback mechanism. The appearance of these oscillations limits the useful gain in the forward-wave mode of amplification to a relatively small value. (TSS)

## Shielding

**2280** (HN-186) SHIELDING EFFECTIVENESS OF SOILS AGAINST INITIAL RADIATION. Wilson, J. H.; Karcher, R. H. (Holmes and Narver, Inc., Los Angeles, Calif. Nuclear Div.). Aug. 1966. Contract W-7405-eng-26, Subcontract 2461. 156p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

For Oak Ridge National Lab., Tenn.

The shielding properties of soils subjected to initial radiation were analyzed, and values of shielding effectiveness were determined including the extremes in behavior which are introduced by such factors as non-hydrogenous chemical composition, bound water content, and free water content. All soils for which complete chemical and mechanical analyses are available were considered. The sources of initial radiation included primary neutrons from weapons and secondary gammas generated in the soil shield. For dry soils it was found that the bound water content is the major factor influencing shielding effectiveness. As the amount of free water in soil is increased, bound water becomes a less important factor. For wet soils it was found that those with high iron content were the least effective shields and those with low iron content, and coincidentally, with high silicon content, were the most effective. It was concluded that, for the purposes of describing shielding effectiveness, soils can be considered in three groups: soils with high bound water and iron content, soils with low bound water and iron content, and soils with intermediate bound water and iron content. (auth)

**2281** (ORNL-TM-1655) DETERMINATIONS OF SHIELD REQUIREMENTS FOR NEUTRON SOURCES. Clark, Francis H. (Oak Ridge National Lab., Tenn.). Oct. 5, 1966. Contract W-7405-eng-26. 30p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The neutron shielding properties of ordinary concrete and of several other useful shielding materials are discussed; the removal cross section method is reviewed and a few remarks are made on the availability of other neutron shielding aids. (auth)

**2282** (UCRL-6698(Del.)) THE CALCULATION OF NONLINEAR RADIATION TRANSPORT BY A MONTE CARLO METHOD. Fleck, Joseph A. Jr. (Lawrence Radiation Lab., Univ. of California, Livermore). Nov. 13, 1961. Contract W-7405-eng-48. 40p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A Monte Carlo method of solving the one-dimensional equations of nonlinear radiation transport is compared with the $S_n$ "characteristics" method of solution. It is concluded that the Monte Carlo method is accurate and stable and furthermore for a given time-cycle length and space-zone size the Monte Carlo method is more accurate than the $S_n$ method. (auth)

## Solid-State Physics

*Refer also to abstracts 2046, 2059, 2132, and 2651.*

**2283** (AD-630701) INVESTIGATION OF TRANSIENT RADIATION DAMAGE IN SEMICONDUCTOR MATERIALS. Final Report, February 1, 1963–September 30, 1965. Corelli, John C.; Frederickson, Arthur R.; Westhead, James W.; Lichtenstein, Roland M.; Willard, H. James Jr. (Rensselaer Polytechnic Inst., Troy, N. Y.). Mar. 1966. Contract DA-36-039-AMC-02165(E). 46p. CFSTI $2.00 cy, $0.50 mn.

A contactless method was developed for measuring induced photoconductivity in silicon. The method was used to search for transient radiation damage effects in silicon specimens irradiated by short bursts of high-energy electrons. The investigation showed that transient radiation damage in silicon at room temperature is a minor effect when compared with permanent damage if the damage is assessed by way of the decay time of induced photoconductivity. No transient damage (as opposed to permanent damage) survives to 1.3 milliseconds after the instant when the damage is produced. Transient radiation damage experiments indicate that in p-type silicon the transient Hall and conductivity voltages decay in about 20 to 50 microseconds. Relatively long saturation times (about 10 to 100 microseconds) are observed in the transient Hall and conductivity voltage following an electron burst. The saturation time decreases with dose accumulation and also decreases as the irradiation temperature of the sample is decreased. Very similar effects also are observed in n-type silicon samples. In both n- and p-type silicon the Hall and conductivity voltages decay with about the same time constant. (TAB)

**2284** (AD-632608) OPTICAL AND MAGNETO-OPTICAL MEASUREMENTS ON MAGNETIC RARE EARTH–COBALT ALLOY FILMS. Stoffel, Axel M.; Strnat, Karl J. (Air Force Materials Lab., Wright-Patterson AFB, Ohio). Mar. 1966. 41p. (AFML-TR-65-445). CFSTI $2.00 cy, $0.50 mn.

The results of an investigation of the Kerr magneto-optic effect and the complex refractive index for pure cobalt and for four ferromagnetic rare earth–cobalt alloys of the composition $RCo_5$ are reported. Magnetic data of all films are also given. The thin film samples were prepared by vapor deposition in ultrahigh vacuum and measured in situ. The effect of annealing and atmospheric corrosion on the optical and magneto-optical properties was investigated. The index of refraction, n, was found to decrease considerably after short exposure to air, while the Kerr effect increased. The rare earth alloys show an optical and magneto-optical behavior similar to that of cobalt. Dispersion curves of n, k, $\Theta_M$, $\epsilon_M$, $Q_0$, and q for wave-lengths of 400 to 616 millimicron are presented. (auth)

**2285** (BNL-10701) CANTED ANTIFERROMAGNETISM OF $CuCl_2 \cdot 2D_2O$. Umebayashi, H.; Shirane, G.; Frazer, B. C.; Cox, D. E. (Brookhaven National Lab., Upton, N. Y.). Oct. 18, 1966. Contract AT(30-2)-Gen-16. 4p. (CONF-661107-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 12th Annual Conference on Magnetism, Magnetic Materials, and Exhibits, Washington, D. C.

Canted antiferromagnetism in $CuCl_2 \cdot 2D_2O$ was confirmed in a neutron-diffraction experiment. The neutron data agree well with the theoretical predictions of Moriya for a minor magnetization component of about $0.1\mu_B$ parallel to the c axis. The angular dependence of the neutron data indicates that the spatial distribution of minor magnetization is quite different from that of the main component. (auth)

**2286** (IS-T-103) FERMI SURFACE OF TUNGSTEN. Girvan, Robert Franz (Ames Lab., Iowa State Univ. of Science and Tech.). July 1966. Contract W-7405-eng-82. 243p. Dep. mn. CFSTI $6.00 cy, $0.25 mn.

Thesis

Impulsive-field de Haas-van Alphen effect measurements were carried out to study the Fermi surface of tungsten. An empirical model was constructed by fitting an equation for the shape of the Fermi surface to the results of this experiment combined with the Gantmakher size effect results of other investigators and with theoretical predictions for the Fermi surface shape. Good overall agreement is obtained between the predictions of the empirical model and experiment showing that a surface with the general features of the Lomer model can account for all of the experimental results. However, the empirical model is imprecise in certain respects, and small changes are indicated for a more precise description of the Fermi surface. (auth)

**2287** (UCB-34P20-T-1) NOTES ON DYNAMIC PROTON POLARIZATION. Jeffries, C. D. (California Univ., Berkeley. Dept. of Physics). Sept. 23, 1966. Contract AT(11-1)-34. 46p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Rate equations are developed for the polarizations of an electron-nuclear spin system consisting of $Nd^{3+}$ spins $\underset{\sim}{S}$ surrounded by proton spins $\underset{\sim}{I}$ within the diffusion barrier and many distant proton spins $\underset{\sim}{I}'$, appropriate to 1% Nd in $La_2Mg_3(NO_3)_{12} \cdot 24H_2O$. A shell-of-

influence model, modified to include diffusion and undesirable magnetic impurities, is used to predict a unique proton relaxation rate, which is found to be in agreement with measurements, in magnitude and in dependence on field and temperature. The coupled rate equations for dynamic proton polarization by saturation of forbidden $I_+S_-$ microwaves transitions are discussed. When the relative abundance of protons to $Nd^{3+}$ ions is correctly taken into account, the microwave power required to saturate the proton polarization is found to agree with the observations. Rate equations are developed and solved for the case of dynamic polarizations in the presence of a phonon bottleneck. In the typical case of 1% Nd: LaMN at 4mm the bottleneck has only a small effect on the proton polarization and saturation behavior. (auth)

**2288** (NP-tr-1434) THE USE OF ELECTRONIC COMPUTERS IN SOLID-STATE PHYSICS FOR A GENERAL TRANSFORMATION OF COMPLICATED MATHEMATICAL EXPRESSIONS (ANALOGUE OF ALGEBRAIC CALCULATION WITH LITERAL SYMBOLS). Scholz, A. Translated by J. B. Sykes (Atomic Energy Research Establishment, Harwell, Eng.), from a German report. 32p. Dep. mn. JCL $3.60 fs, $1.16 mf.
Handwritten MS. copy.

The advantages of using electronic computers in the theoretical treatment of complex physical processes and phenomena are discussed. Information is presented on programming computers in solid-state physics, and some typical examples of programming are included. (J.H.M.)

**2289** GROWTH OF COPPER WHISKERS AND DETERMINATION OF THEIR CRYSTAL STRUCTURE BY ELECTRON SCATTERING. Moessler, G.; Stangler, F. (Univ., Vienna). Acta Phys. Austr., 23: 252-65(1966). (In German).

The types of crystal structure of Cu whiskers were determined microscopically. Their growth mechanism was outlined and the mechanism leading to growth disturbances was determined. The experimental results showed that a large part of the growth disturbances can be ascribed to too narrow a range of melt and site of growth. (J.S.R.)

**2290** MEASUREMENT OF THE RESISTANCE VARIATION OF GERMANIUM AND SILICON DURING PULSED REACTOR IRRADIATION. Walther, H.; Weiss, H. (Oesterreichische Hochschule, Vienna). Acta Phys. Austr., 23: 240-51(1966). (In German).

Corpuscular and quantum radiation affects the conductivity of Ge and Si. Pulse operation on the TRIGA Mark II Reactor offers the possibility of investigating these effects at very high short-lived radiation intensities. For this purpose an apparatus was constructed which makes possible the measurement of resistance changes up to a detection limit of $10^{-5}$ during the pulses. Separation of the effects can be made into a residual neutron and a transient $\gamma$ radiation fraction. Both effects lie within the framework of the pleasant theory. In the residual neutron effect a delay in the resistance change was found, which could not be completely explained because of the high limits of error of the analog data recording. It is therefore necessary to transfer to digital data detection and processing. (tr-auth)

**2291** REACTOR AND LINEAR ACCELERATOR INDUCED EFFECTS IN DIELECTRICS. Frankovsky, F. A.; Shatzkes, M. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-13: No. 5, 8-21(Oct. 1966).

The currents induced by nuclear radiation from a pulsed reactor on several commercial capacitors are compared with those induced by the electron beam of a linear accelerator (LINAC) source. Dependence of the radiation induced current on applied voltage, geometry, dose, and dose rate is contrasted for Mylar, polystyrene, mica, tantalum, glass, and ceramic capacitors. These effects are analyzed in terms of models appropriate for the various capacitors, and values of parameters defining these relations are given. The relative effectiveness of neutron and gamma radiation in producing induced currents in these capacitive elements at the reactor environment was also obtained. (auth)

**2292** A STUDY OF THE (222) FORBIDDEN REFLECTION IN GERMANIUM AND SILICON. Colella, R.; Merlini, A. (CCR-EURATOM, Ispra, Italy). Phys. Status Solidi, 18: 157-66(Nov. 1, 1966).

The absolute x-ray intensity of the (222) forbidden reflection is measured in single crystals of Ge and Si by using monochromatic $CoK_\alpha$ radiation. The inclusion of multiple reflections in the measured intensity is avoided by a suitable choice of the azimuthal angle. The values of the structure factors $F_{222}$, deduced from the experimental intensities, are 1.54 and 1.08 respectively for Si and Ge. The $F_{222}$ value for Si is not significantly affected by mechanical damage or by fast-neutron irradiation up to a dose of $3 \times 10^{20}$ nvt at about 100°C. Furthermore, a search for the (222) reflection of Si with neutron diffraction and for the (420) x-ray reflection in Si crystals doped with boron yields negative results. These results do not agree with those of other authors on the increase in the intensity of the (222) reflection and on the appearance of (200) and (420) reflections in doped Ge and in neutron-irradiated diamond and Ge crystals. Therefore, the true intensity of the (222) reflection does not appear to be appreciably affected by lattice defects, but it is due to scattering by electrons of the covalent bonds. (auth)

**2293** RADIATION-INDUCED POINT DEFECT CLUSTERS IN COPPER AND GOLD. I. CLUSTERS PRODUCED IN ENERGETIC DISPLACEMENT CASCADES. Merkle, K. L. (Argonne National Lab., Ill.). Phys. Status Solidi, 18: 173-88 (Nov. 1, 1966).

The transmission electron microscope technique was used to investigate the defect structures introduced by bombardment of thin films of copper and gold with heavy particles. The black spot defects in gold can be shown to be produced directly in displacement cascades if the energies of the cascades are high enough. The size of the observed defect clusters increases with increasing primary energy. A very energetic primary can produce a bunch of closely spaced defect clusters. Charged-particle irradiations of copper indicate that, contrary to gold, not every primary event above a certain threshold energy is observed. This is interpreted as being due to the formation of non-overlapping subcascades, each of which might form a stable cluster but is generally too small to be observed under these experimental conditions. Those clusters in copper and gold identified unambiguously are vacancy-type. (auth)

**2294** RADIATION DAMAGE AND XENON RELEASE IN QUARTZ AND FUSED SILICA FOLLOWING ION BOMBARDMENT. Matzke, Hj. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Phys. Status Solidi, 18: 285-95(Nov. 1, 1966).

Single-crystalline quartz and fused silica were bombarded with 40-keV xenon ions to give integrated ion doses up to $2 \times 10^{16}$ ions/cm$^2$. At low dose ($8 \times 10^{10}$ ions/cm$^2$) diffusional release processes dominated with activation enthalpies of 58 and 61 kcal/mole for quartz (diffusion along and perpendicular to the c-axis respectively) and 72 kcal/mole for fused silica. Diffusion in the amorphous phase was markedly slower than diffusion in the crystalline phase. At doses $\geq 4 \times 10^{13}$ ions/cm$^2$ radiation damage in the form of a phase change to a quasi-amorphous state occurred in quartz, as revealed by reflection electron diffraction. The annealing of this structural damage coincided with enhanced thermally activated gas release at temperatures below those of volume diffusion. Fused silica showed a similar enhanced release at high bombardment dose. Thus, the quasi-amorphous phase produced by ion bombardment is different from that of fused silica. The present results indicate further, in agreement with the literature on neutron-irradiated quartz and fused silica, that both materials approach a common state at a high level of radiation damage. (auth)

**2295** DIFFUSION OF TRITIUM FROM LITHIUM FLUORIDE. Matzke, Hj. (Technical Univ., Brunswick). Phys. Status Solidi, 18: 317-24(Nov. 1, 1966).

The release of tritium from neutron-irradiated LiF single crystals ($5.4 \times 10^{16}$ nvt, at approximately 300°C) follows the relation $D = 6 \exp(-38{,}800/RT)$ cm$^2$/sec between 500°C and the melting point. Volume diffusion kinetics are obtained from isothermal experiments. The tritium diffusion is found to be essentially independent of the neutron dose ($3 \times 10^{16}$ to $3 \times 10^{17}$ nvt) and nominal temperature during irradiation (−80 to 200°C). Data obtained following ion bombardment confirm these results. (auth)

**2296** ON A SIMPLE DERIVATION OF THE AMPLITUDES OF THE ELECTRON BEAMS TRANSMITTED AND SCATTERED BY A CRYSTAL CONTAINING PLANAR INTERFACES: IMAGES OF SUBGRAIN BOUNDARIES. Gevers, R.; van Landuyt, J.; Amelinckx, S. (SCK-CEN, Mol, Belg.). Phys. Status Solidi, 18: 325-42(Nov. 1, 1966).

A calculation is made of the amplitudes of the waves transmitted and scattered by a plate-shaped foil formed by the superposition of two parallel plate-shaped crystals. The diffraction vectors, the excitation errors, the extinction distances, the absorption lengths, and the phase angles of the Fourier coefficients of the internal potential are assumed to be different in the two crystals. The amplitudes can be readily derived from the corresponding expressions for a perfect plate-shaped foil. These expressions are found by considering the transmitted and scattered beams to arise from the interference of two plane waves with slightly different wave vectors. The method can be generalized to a plate-shaped foil formed by the superposition of more than two parallel crystals. Assuming the column approximation to be valid a brief discussion is given of the different types of images resulting from planar interfaces. The images due to low-angle subgrain boundaries are discussed in some detail and observations are presented. These images are often complicated by the superpositions of wedge crystal pseudo-periodic fringe patterns and the moiré type of fringe patterns, which are strictly periodic. (auth)

**2297** REACTION KINETICS OF STAGE III RECOVERY IN ALUMINUM AFTER NEUTRON IRRADIATION. Isebeck, K.; Mueller, R.; Schilling, W.; Wenzl, H. (Technische Hochschule, Munich). Phys. Status Solidi, 18: 427-39(Nov. 1, 1966).

Low-temperature neutron irradiation of high-purity aluminum (up to a dose of $7.2 \times 10^{17}$ nvt) produces a resistivity change of $\Delta\rho = 5 \times 10^{-8}$ Ωcm measured at 90.2°K. The recovery is studied for isochronal and isothermal annealing in the stage III temperature range from 180 to 263°K. This entire recovery region is uniquely activated with an activation energy of (0.58 ± 0.02) eV. The recovery mechanism is found to be bimolecular, the initial recovery being due to the correlated recovery of defects situated at small relative distances in defect clusters. The last 50% of stage III follow second order kinetics. The capture volume for interstitial-vacancy recombination can be determined from the measurements. The results support the theory that in stage III interstitial atoms migrate freely and recombine with vacancies. (auth)

**2298** THE CRITICAL SHEAR STRESS OF CUBIC CRYSTALS WITH DEFECTS OF TETRAGONAL SYMMETRY. III. ELECTRON- AND NEUTRON-IRRADIATED ALUMINUM AS WELL AS ELECTRON-IRRADIATED COPPER. Frank, W. (Max-Planck-Institut fuer Metallforschung, Stuttgart. Technische Hochschule, Stuttgart). Phys. Status Solidi, 18: 459-64 (Nov. 1, 1966). (In German).

Electron- and neutron-irradiated aluminum and electron-irradiated copper contain dispersed interstitial atoms in dumbbell configurations. It is shown that in these cases the radiation-induced increase of the critical resolved shear stress can be explained quantitatively in terms of elastic short-range interactions between dislocations and interstitials close to the dislocation slip planes. (auth)

**2299** APPLICATION OF BOUND-EXCITON OPTICAL SPECTRA IN THE STUDY OF RADIATION DAMAGE IN CRYSTALS. Lider, K. F.; Novikov, B. V.; Permogorov, S. A. (State Univ., Leningrad). Phys. Status Solidi, 18: K1-4(Nov. 1, 1966).

In ion- and deuteron-bombarded CdS crystals, bound-exciton emission was studied at 77 and 4.2°K. Bombardment with ions in a glow discharge caused the appearance at 4.2°K of a new line with a wavelength of 4870.1 Å in both luminescence and absorption spectra. At 77°K a line with its center near 4886 Å appeared in the luminescence spectrum of crystals bombarded with 6-MeV deuterons. The appearance of both these lines is associated with an increase in the number of sulfur vacancies in a near-surface layer. Additional evidence for the formation of sulfur vacancies was provided by a study of the luminescence spectrum of CdS crystals treated in Cd vapor at 400°C. (A.G.W.)

**2300** INFRARED ABSORPTION BY EXCITONS DUE TO PHOTOIONIZATION AND INTRABAND LATTICE SCATTERING. Moskalenko, S. A.; Khadshi, P. I. (Inst. of Applied Physics, Kishinev). Phys. Status Solidi, 18: 379-90(Nov. 1, 1966).

A quantum mechanical theory is developed for infrared absorption by excitons due to photoionization and intraband lattice scattering. The theory involves the interaction of the excitons with the acoustic and optical phonons. The Maxwellian and Bose–Einstein distribution functions and the possible locations of the simple exciton band extremum are taken into account. The effect of the exciton photoionization is observable at the threshold frequency at comparatively low exciton concentrations. (auth)

**2301** RECOMBINATION LUMINESCENCE SPECTRA OF SILVER-ACTIVATED ALKALI METAL HALIDE CRYSTALLOPHOSPHORS. Parfianovich, I. A.; Penzina, E. E. Zh. Prikl. Spektrosk., 5: 335-9(Sept. 1966). (In Russian).

The thermoluminescence spectra of alkali metal halides activated by silver and excited with x rays at 90°K and 295°K were measured. Complex spectral composition and redistribution of emission band intensities were observed during the nonisothermal relaxation processes. Emission bands of "atomic" (induced by x rays) centers were detected in thermoluminescence as well as ionic emission bands. A characteristic feature of thermoluminescence of KCl–Ag and KBr–Ag is the presence of the green emission band. The nature of this band is not finally established. (auth)

**2302** COHERENT BREMSSTRAHLUNG FROM Si SINGLE CRYSTAL. II. Kifune, Tadashi; Kimura, Yoshitaka; Kobayashi, Masaaki; Kondo, Kunitaka; Nishikawa, Tetsuji (Tokyo Univ.). J. Phys. Soc. Jap., 21: 1907-16(Oct. 1966).

The observed interference effect of bremsstrahlung produced by high energy electrons in a single crystal of silicon is analyzed. Numerical calculations have been carried out on the total cross section and the linear polarization. The interference part of the cross section is sensitive to the value of atomic form factor at a small momentum transfer. Assuming the form factor of Si atoms determined by the x-ray diffraction, one obtains a good agreement between the theory and the experiment. From the observed fine structure of bremsstrahlung spectrum, a path length of electron in which the interaction is coherent is estimated. Effects of photon beam collimation, temperature of the crystal, and inelastic process due to atomic electrons are discussed. (auth)

**2303** NEW INFRARED ABSORPTION IN NEUTRON-IRRADIATED LITHIUM FLUORIDE. Kamikawa, T.; Kazumata, Y.; Ozawa, K. (Japan Atomic Energy Research Inst., Tokyo). Phys. Status Solidi, 17: 645-55(Oct. 1, 1966).

New absorption bands are observed in the near-infrared region in neutron-irradiated and thermally bleached pure LiF crystals after aging. At low temperatures these bands show fine structures. The characteristics of these bands and lines and the factors affecting their growth are studied. From its growth behavior and other properties, it is suggested that the 0.914 μm band is due to intrinsic defects. The other infrared bands are attributed to the intrinsic defects associated with tritium produced by the $^6Li(n,\alpha)^3H$ nuclear reaction. The observed results are interpreted on the basis of this model. (auth)

**2304** EFFECT OF DISLOCATION DIPOLES ON THE SHAPE OF THE NUCLEAR MAGNETIC RESONANCE LINE. Greenberg, B. A. (Inst. of Metal Physics, Academy of Sciences, Sverdlovsk, USSR). Phys. Status Solidi, 17: 673-81(Oct. 1, 1966).

The effect of dislocation dipoles on the broadening of a NMR line is studied. The shape of the satellite line is determined. The line width is obtained as a function of the dipole concentration, the dipole length, and the relative orientation of the dipole and the external constant magnetic field. The shape of the central line is also determined. The shape function of the central line is presented for certain relative orientations of the dipole and the magnetic field. (auth)

**2305** MAGNETIC SUSCEPTIBILITY AND ELECTRONIC SPECIFIC HEAT OF TRANSITION METALS AND ALLOYS. IX. RE-CALCULATION FOR Zr, Nb, AND Mo METALS. Shimizu, Masao; Katsuki, Atsushi; Ohmori, Kazuhiko (Univ. of Nagoya, Japan). J. Phys. Soc. Jap., 21: 1924-8(Oct. 1966).

A new density of states curve for a series of Zr, Nb, and Mo metals and their alloys is obtained from new data of low temperature specific heat for this series on the basis of the rigid band model. Temperature variations of electronic specific heat and spin paramagnetic susceptibility for Zr, Nb, and Mo metals are calculated by using the new density of states. These are compared with the previously calculated results and experimental ones. Both old and new calculated results are qualitatively similar at high temperatures. For Nb metal the new value of the low temperature specific heat coefficient is found to be fairly smaller than the old one, so that the sign of the molecular field coefficient $\alpha$, which is estimated by comparison between temperature variations of the observed and calculated susceptibilities, becomes positive in contrast to the negative value of $\alpha$ estimated in the previous work. (auth)

**2306** STUDIES ON THE ELECTRICAL PROPERTIES OF URANIUM OXIDES. II. NON-STOICHIOMETRIC $U_3O_8$. Singh, N.; Karkhanavala, M. D. (Atomic Energy Establishment, Trombay, India). Phys. Status Solidi, 17: 501-8(Oct. 1, 1966).

The electrical conductivity $\sigma$ and Hall coefficient $R_H$ are measured over the range 250 to 400°K on pellets of $U_3O_8$ sintered for periods up to 120 hr at 900°C. The sintering results in a progressive decrease of the O/U ratio from 2.666 to 2.63 accompanied by an increase in the density from 5.62 ("green" density) to 8.08 g/cm$^3$. The values of the electrical conductivity are corrected for porosity. With decreasing O/U ratio, the conductivity and Hall mobility increase, while the conductivity activation energy decreases. The results for the highly sintered (96.5% of theoretical density) material of composition $UO_{2.63}$ are interpreted on the basis of the hopping of small polarons. (auth)

**2307** ELECTRON SPIN RESONANCE OF RADIATION-PRODUCED RADICALS IN SINGLE CRYSTALS OF 2,6-BUTYL-HYDROXYTOLUENE. Schoffa, G. (Technische Hochschule, Karlsruhe, Ger.). Phys. Status Solidi, 17: 683-9(Oct. 1, 1966). (In German).

Electron-paramagnetic resonance of stable radicals, obtained by x irradiation of 2,6-butylhydroxytoluene (BHT) single crystals shows a hyperfine structure of four lines with the intensity ratio 1 : 3 : 3 : 1. This is due to the interaction of the unpaired electrons of the semi-quinone radical of BHT with three protons of the methyl group. The absence of an anisotropic component in the interaction may originate from the rotation of the methyl group in the solid. The spin densities of the radical are calculated using the MO–SCF method of McLachlan and compared with experimental data. (auth)

**2308** ELECTRON MICROSCOPY STUDIES OF DISLOCATIONS IN DEFORMED COPPER SINGLE CRYSTALS. III. DE-

TERMINATION OF DISLOCATION DENSITY. Essmann, U. (Max-Planck-Institut fuer Metallforschung, Stuttgart. Technische Hochschule, Stuttgart). Phys. Status Solidi, 17: 725-37 (Oct. 1, 1966). (In German).

Copper single crystals, orientated for single slip, are deformed by tension. In order to minimize the loss of dislocations during the preparation of the thin foils the crystals are irradiated with fast neutrons after deformation. The density of dislocations with a primary Burgers vector may be expressed as a linear function of the flow stress ($\rho_{pr} \sim \tau$). The density of the dislocations with non-primary Burgers vectors (secondary dislocations) is a quadratic function of the flow stress ($\rho_{sec} \sim \tau^2$). These results may be attributed to intensive reactions between primary and secondary dislocations. (auth)

**2309** CHARGE OF DISLOCATIONS IN PURE AND γ-IRRADIATED LiF. Rueda, F.; Dekeyser, W. (Studie van de Vaste Stof, Ghent). Phys. Status Solidi, 17: 739-44(Oct. 1, 1966).

The electrical charge of newly created dislocations in non-irradiated and γ-irradiated LiF is studied by the indentation method. In both cases the dislocations are negatively charged. Subsequent annealing after irradiation produces a reversal of sign of that charge, the first isoelectric temperature being located in the range of bleaching of F and M centers. These effects are attributed to negative vacancies produced by irradiation and thermal bleaching. (auth)

**2310** LOW-TEMPERATURE HEAT CAPACITY AND THERMODYNAMICAL FUNCTIONS OF FERROMAGNETIC URANIUM PHOSPHIDE $U_3P_4$. Stalinski, B.; Bieganski, Z.; Troc, R. (Inst. of Structural Research, Wroclaw. Technical Univ., Wroclaw). Phys. Status Solidi, 17: 837-41(Oct. 1, 1966).

The heat capacity of uranium phosphide, $U_3P_4$, is measured from 22.5 to 349.0°K in an adiabatic calorimeter. A λ-type anomaly observed at 138.3°K is due to a ferromagnetic order-disorder transition. Calculations are made of the thermodynamic functions, $S^0$, $(H^0 - H_0^0)$, and $-(F^0 - H_0^0)/T$ and the lattice and magnetic contributions to the heat capacity of this compound. The entropy change for the magnetic transition is estimated to be 3.09 cal $mol^{-1}$ $deg^{-1}$. (auth)

**2311** CONDUCTION MECHANISM IN URANIUM DIOXIDE. Devreese, J. (Solid State Physics Dept., Mol, Belg.); De Coninck, R.; Pollak, H. Phys. Status Solidi, 17: 825-9(Oct. 1, 1966).

Experimental data on the thermoelectric power and electrical conductivity of nearly stoichiometric $UO_{2+x}$ single crystals are presented and analyzed in order to estimate the activation energy of the drift mobility. These results are compared with the predictions of small polaron theory. Although some further analysis is required, there is evidence that conduction in $UO_{2+x}$ occurs via a hopping mechanism. (auth)

**2312** DIRECTIONAL EMISSION OF CHARGED PARTICLES FROM A SINGLE CRYSTAL UNDER ION BOMBARDMENT. Yurasova, V. E.; Buchanov, V. M.; Golo, M. (Moscow State Univ.). Phys. Status Solidi, 17: K187-90(Oct. 1, 1966).

The angular and energy distributions of secondary electrons and ions ejected from the (100) plane of a Cu single crystal under 4.5-keV argon ion bombardment were investigated simultaneously. The ion emission data show that the mean energy of the ions is dependent on the ejection directions; it has a maximum value in the close-packed directions [110]. A higher percentage of slow ions was detected in the spectra for directions far from [110]. The most probable electron ejection energies are about 4 to 5 eV and show no noticeable dependence on the ejection direction. The value of the secondary electron energy depends on the angle of electron ejection from the single crystal, but not on the crystallographic axis. (A.G.W.)

**2313** VERIFICATION OF THE MAGNETIC SUSCEPTIBILITY AS A FUNCTION OF TEMPERATURE BY CRITICAL DIFFUSION OF NEUTRONS IN IRON. Konstantinovic, J. (Boris Kidric Inst. of Nuclear Science, Belgrade). Solid State Commun., 4: 425-9 (Sept. 1966). (In French).

The temperature dependence of neutron scattering by iron was measured on the EL3 Saclay Pile for temperatures from $T_c$ to $T_c$ + 30°C and it was analyzed assuming the form $I = [C(T - T_c)^B + Aq^2]^{-1}$ (I = intensity; $\vec{nq}$ = momentum transfer) and from the measured intensities the coefficients B, C, and A are determined. It may be concluded, in the limit of the interval $T_c$ + 0.5 to $T_c$ + 30°C, that magnetic susceptibility obeys the law: $1/\chi \sim (T - T_c)^B$, with $B = 1.33 \pm 0.01$. (auth)

**2314** ELECTRIC RESISTIVITIES AND SOLID SOLUBILITIES OF SOME RARE-EARTH METALS IN SILVER. Bijvoet, J.; van Dam, A. J.; van Beek, Flora (Univ., Amsterdam). Solid State Commun., 4: 455-8(Sept. 1966).

By measuring the electrical resistivities, the solubilities of eight rare-earth metals in silver were determined as well as the resistivities of silver with 1 at. % rare-earth metal. Results are in agreement with measurements on gold as a solvent with the exception of ytterbium which is divalent in silver. (auth)

**2315** APPLICATIONS OF NEUTRON DIFFRACTION. Bacon, G. E. (Atomic Energy Research Establishment, Harwell, Eng.). Endeavour, 25: 129-35(Sept. 1966).

It is shown by means of simple examples, the way in which detailed and quite unique information concerning solids can be obtained from experiments with neutron beams. A general discussion of the neutron scattering techniques is also presented. (M.O.W.)

**2316** WAVE/PARTICLE DUALITY IN PROTON CHANNELING IN CRYSTALS. Chadderton, L. T. (North American Aviation Science Center, Thousand Oaks, Calif.). Phys. Lett., 23: 303-4 (Oct. 31, 1966).

Though it has become conventional to discuss the channeling of energetic protons through crystals in classical terms certain experimental observations suggest a wave behavior. (auth)

**2317** ACTIVATION ENERGY IN THE NaCl THERMOLUMINESCENCE. Aramu, F.; Brovetto, P.; Rucci, A. (Univ., Cagliari, Italy). Phys. Lett., 23: 308-9(Oct. 31, 1966).

Experimental results giving some evidence of activation energy varying with temperature in NaCl thermoluminescence are reported. (auth)

**2318** A NEW METHOD TO DETERMINE THE MASS OF MICROFINE PARTICLES. Murayama, Y. (Hitachi Central Research Lab., Tokyo). Phys. Lett., 23: 332-3(Oct. 31, 1966).

A possibility is suggested how to measure the mass of microfine particles using Mössbauer-type resonant emission or absorption of γ rays. In contrast to bulky specimens, the γ-ray spectrum of fine particles may suffer any shift due to recoil. (auth)

**2319** ANTIFERROMAGNETISM IN CHROMIUM ALLOYS. I. NEUTRON DIFFRACTION. Koehler, W. C. (Oak Ridge National Lab., Tenn.); Moon, R. M.; Trego, A. L.; Mackintosh, A. R., Phys. Rev., 151: 405-13(Nov. 11, 1966). (ORNL-P-2343)

The magnetic properties of Cr alloys containing small amounts of the transition metals V, Mn, Nb, Mo, Tc, Ru, Rh, Ta, W, and Re were studied by powder and, in some cases, single-crystal neutron-diffraction techniques. Mn, Tc, Ru, Rh and Re, which increase the electron-to-atom ratio, also increase the Néel temperature and magnetic moment, which reach maximum values of about 700°K and 0.75 $\mu_B$, compared with 311°K and 0.40 $\mu_B$ for pure Cr. The wave vector of the magnetic structure also increases until, at a concentration of about 1%, it changes abruptly to $2\pi/a$ and the structure becomes commensurable with the lattice. The addition of V, Nb or Ta, which reduces the electron-to-atom ratio or of Mo or W, for which it remains constant, diminishes the Néel temperature and moment and reduces the wave vector. Ta is the most effective in modifying the properties of pure Cr, followed by Nb and V, W, and Mo in that order. In all cases studied the transition temperature from a transverse- to a longitudinal-wave magnetic structure is reduced by alloying. These observations can be explained by the two-band model of Lomer, which was studied in detail by Fedders and Martin. The wave vector of the magnetic periodicity connects electron and hole sheets of the Fermi surface and its magnitude and rate of change with electron concentration are in semiquantitative agreement with the energy-band calculations of Loucks. The Néel temperature is proportional to the ordered moment, and varies very rapidly with electron concentration in a way which can be qualitatively explained by the form of the Fermi surface. The variation of the ordered moment with temperature follows the BCS superconducting energy-gap function, as predicted by the theory. (auth)

**2320** MAGNETIC STRUCTURES OF HOLMIUM. I. THE VIRGIN STATE. Koehler, W. C.; Cable, J. W.; Wilkinson, M. K.; Wollan, E. O. (Oak Ridge National Lab., Tenn.). Phys. Rev., 151: 414-24(Nov. 11, 1966). (ORNL-P-2273)

Neutron-diffraction measurements were made on single-crystal specimens of holmium at temperatures ranging from room temperature to 4.2°K. Below the Néel temperature of 133°K, the moments order in a helical structure in which the c axis is the screw axis. The interlayer angle varies from about 50° per layer at $T_N$ to 30.0° per layer at 4.2°K. Below about 20°K the structure is a conical configuration in which there is a net moment of 1.7 $\mu_B$ parallel to the c axis. The configuration of moments in the basal plane at 4.2°K is a distorted helical one in which moments of 9.5 $\mu_B$ are bunched around the easy b directions in the plane. (auth)

**2321** TRAPPING AND ANNIHILATION OF ELECTRONS AND POSITIVE HOLES IN KCl–TlCl. Delbecq, Charles J.; Ghosh, Amal K.; Yuster, Philip H. (Argonne National Lab., Ill.). Phys. Rev., 151: 599-609(Nov. 11, 1966).

During $\gamma$ irradiation at 77°K, $Cl_2^-$ and thallium atoms ($Tl^0$) are formed in KCl – TlCl crystals. On warming the irradiated crystals, two glow peaks are observed. The low-temperature glow peak at 208°K is caused by the diffusion of $Cl_2^-$ and the subsequent electron-hole annihilation involving nearby pairs of $Cl_2^-$ and $Tl^0$. In addition to diffusing into the neighborhood of $Tl^0$, a $Cl_2^-$ can diffuse into the neighborhood of a $Tl^+$ and become retrapped to form $Tl^{++}$. The high-temperature glow peak at 300°K results when electrons are thermally released from thallium atoms into the conduction band and recombination of these electrons and $Tl^{++}$ takes place. Spectral analysis of the low-temperature glow peak shows that it consists of two emission bands with peaks at 410 and 298 nm while the high-temperature glow peak consists only of the 298-nm band. The processes which give rise to these emissions are discussed. The optical absorption of $Tl^0$ and $Tl^{++}$ has been measured. The absorption spectrum of $Tl^0$ consists of very weak bands at 1500 and 1260 nm, a strong band at 380 nm, and weak bands at 250, 300, and 640 nm. $Tl^{++}$ has strong absorption bands at 220, 262, 294, and 364 nm. The concentrations of $Tl^0$ and $Tl^{++}$ produced by irradiation were determined by measuring the decrease in height of the A band of $Tl^+$ and thus determining the decrease in the concentration of $Tl^+$. From the concentration of $Tl^0$ and $Tl^{++}$ and the optical-absorption spectra of these species it was possible to calculate the oscillator strengths of the $Tl^0$, $Tl^{++}$, and $Cl_2^-$ bands. (auth)

**2322** GENERATION AND RECOMBINATION OF HOLES AND ELECTRONS IN ANTHRACENE. Kepler, R. G.; Coppage, Floyd N. (Sandia Lab., Albuquerque, N. Mex.). Phys. Rev., 151: 610-14 (Nov. 11, 1966). (SC-DC-66-1613)

The generation of electrons and holes in anthracene crystals by x rays from a 600-kV pulsed x-ray source was studied. The average energy deposited per electron-hole pair created W was found to be $3 \times 10^3$ eV. The number of carriers generated was independent of temperature from –25 to 25°C and depended linearly upon the x-ray intensity. At high intensity, recombination effects become important and the electron-hole recombination coefficient was found to be $(3 \pm 1) \times 10^{-6}$ cm$^3$ sec$^{-1}$. The value of the recombination coefficient is shown to be in good agreement with a theoretical value calculated on the basis of a very small mean free path for electrons and holes, and the large value of W is explained in terms of this model. These results imply that only a very small fraction of electron-hole pairs produced by a low-energy process such as a band-to-band transition would appear as free carriers in anthracene, and provide a possible explanation for the commonly observed exponential temperature dependence of photoconductivity. (auth)

**2323** ELECTRON MOMENTUM DISTRIBUTION IN SILICON AND GERMANIUM BY POSITRON ANNIHILATION. Erskine, James C.; McGervey, John D. (Western Reserve Univ., Cleveland). Phys. Rev., 151: 615-20(Nov. 11, 1966). (COO-1297-3)

The angular correlation of positron-annihilation radiation from single crystals of silicon and germanium was measured for three different orientations of each crystal. The distributions for the three orientations differ greatly from one another, but each germanium distribution differs from the corresponding silicon distribution only by a scale factor which arises from the difference in the lattice constant. Data are compared with curves calculated using the nearly free-electron approximation for the electron's momentum. It is assumed that the occupied electron states in the crystal fill the Jones zone, a regular dodecahedron bounded by the set of {220} planes in momentum space, and the energy gap is taken to be an adjustable parameter. The fit is extremely good for the radiation emitted in the (110) plane but not so good for the (111) and (100) orientations. Possible reasons for the discrepancies are discussed. (auth)

**2324** ENERGY DEPENDENCE OF ANISOTROPY OF DEFECT PRODUCTION IN ELECTRON-IRRADIATED DIAMOND-TYPE CRYSTALS. I. EXPERIMENTAL MEASUREMENTS ON n AND p-TYPE SILICON. Haddad, I. N.; Banbury, P. C. (Univ. of Reading, Eng.). Phil. Mag. (8), 14: 829-40(Oct. 1966).

Studies are reported of damage rate deduced from room-temperature conductivity measurements on n- and p-type floating zone silicon samples ~20 $\mu$ thick, subject to electron irradiation at energies from 0.3 to 2.0 MeV. For the n-type material, each specimen was cut to an orientation such that, by rotating the specimen, successive irradiations could be given along a chosen pair of crystallographic directions making equal angles with the specimen face. The results show repeated crossing over of the damage rate versus energy curves for different orientations. With increasing energy, the beam direction giving the highest rate changes from ⟨111⟩ to ⟨110⟩ to ⟨100⟩ to ⟨111⟩ in this range. Arguments are presented that the carrier removal rate depends almost entirely on the introduction rate of single primary defects. A correction is applied to our earlier published results following Stein's recent work, and agreement on the sequence of orientation effects is then found with the present measurements. On p-type material, in separate irradiations at normal incidence on oriented specimens, slight annealing and a lower carrier removal rate are seen; the orientation and energy dependence are similar to n-type up to ~0.7 MeV, above which a steeper energy dependence and highest damage rate along ⟨100⟩ up to ~1.0 MeV are attributed to the creation of significant numbers of primary divacancies. (auth)

**2325** DYNAMICAL JAHN–TELLER EFFECT IN ALKALI HALIDE PHOSPHORS CONTAINING HEAVY METAL IONS. Toyozawa, Yutaka; Inoue, Masaharu (Tokyo Univ.). J. Phys. Soc. Japan, 21: 1663-79(Sept. 1966).

Possible patterns of vibration-induced splitting in the absorption band of localized electrons in solid are investigated within the Condon approximation. The modes of lattice vibrations around the imperfection which give rise to the level splitting of degenerate excited states are classified into active and potentially active modes according as they cause the absorption band to split or not. The result is applied to the analysis of the absorption bands of $Tl^+$-like ions in alkali halides. One can explain the triplet structure of the C band and the doublet structure of the A band with its temperature sensitive asymmetry, by introducing the coupling constant c between the p electron and the trigonal lattice vibrations as a single adjustable parameter. The dependences of c upon the host alkali halide and on the charge of the impurity ion are explained by a point-charge plus point-dipole model for the neighboring halide ions. (auth)

**2326** ON QUADRUPOLE SPALLATION MAGNITUDE IN MOESSBAUER SPECTRA OF IRON COMPOUNDS. Baranovskii, V. I. (Leningrad State Univ.). Zh. Strukt. Khim., 7: 141-3(Jan.-Feb. 1966). (In Russian).

Quadrupole spallation in the Moessbauer spectrum of $^{57m}Fe$ is defined by the expression $\Delta = \frac{1}{2}\, eq(1-\gamma)Q$, where e is the charge of the electron, Q the quadrupole moment of the nucleus, $(1-\gamma)$ the so-called antishielding factor, and q the electric field gradient caused by unfilled p and d shells. When analyzing the available experimental data, it must be ascertained what part of the spallation is due to the presence of an unbalanced 3d electron. The value of $\Delta$ was determined by H. Eicher and L. G. Lang et al. method, used for studying the wave function of the highest populated levels of certain iron complexes. These complexes were viewed on the basis of the ligand field theory, making allowances for molecular orbits. Decomposition of the levels corresponding to various molecular orbits in the octahedral iron complexes was graphically illustrated. The explanation for the absence of quadrupole spallation in the spectra of ferricyanides agreed with previous findings. (TTT)

**2327** MONOVALENT SAMARIUM IN POTASSIUM CHLORIDE. Fong, Francis K. (North American Aviation Science Center, Thousand Oaks, Calif.); Cape, John A.; Wong, Eugene Y. Phys. Rev., 151: 299-303(Nov. 4, 1966).

Potassium chloride crystals were doped with $Sm^{2+}$ ions to concentrations of $5 \times 10^{19}$ cm$^{-3}$, resulting in identifiable $Sm^{2+}$ absorption spectra. Heating of the doped crystals in K vapor produces no visible change in the samples. Exposure to gamma irradiation at room temperature leads to a decrease in the $Sm^{2+}$ absorption bands accompanied by an equivalent growth in the near infrared of a characteristic spectrum that can be explained in terms of electric dipole transitions between the $4f^6 6s^1$ and $4f^5 6s^2$ configurations of the $Sm^{1+}$ ion. The conclusion that $Sm^{2+}$ ions are reduced to $Sm^{1+}$ by the capture of an electron is supported by the observation that the growth rate of the $Sm^{1+}$ bands is equal to the decay rate of the $Sm^{2+}$ bands. Magnetic susceptibility and electron paramagnetic resonance (EPR) observations are shown to be consistent with the reduction hypothesis. (auth)

**2328** CHANNELING OF 375-keV PROTONS THROUGH SILICON. Eisen, F. H. (North American Aviation Science Center, Thousand Oaks, Calif.). Phys. Lett., 23: 401-2(Nov. 14, 1966).

The energy spectra and angular distribution of 375-keV protons channeled through Si were measured. The results indicate that transmission along axial channels is important at this energy. (auth)

**2329** CHANNELING OF $D^+$ AND $He^+$ IONS IN GOLD CRYSTALS. Andreen, C. J.; Hines, R. L. (Northwestern Univ., Evanston, Ill.). Phys. Rev., 151: 341-8(Nov. 4, 1966).

The transmitted intensity of $D^+$ and $He^+$ ions through gold crystals in the forward direction is measured as a function of crystal orientation for energies near 15 keV. The gold crystals have a (100) orientation and are mounted in a goniometer that can tilt the foil normal up to 60° away from the incident beam direction and can rotate the foil about its normal. The detector can be tilted relative to the beam direction up to a maximum angle of 58°.

Pronounced peaks are found in the transmitted intensity at low-index directions. Both directional and planar channeling are present. The peak widths are successfully interpreted in terms of a channel-entrance peak width and a channel-exit peak width. Energy analysis shows that the energy of the transmitted ions also has peaks in the low-index directions. The experimental values for the energy loss of the randomly scattered part of the ion beam agree with the theoretical predictions. (auth)

**2330** NUCLEAR MAGNETIC RESONANCE IN POLARIZED NUCLEI. Matthias, E.; Holliday, R. J. Univ. of California, Berkeley). Phys. Rev. Lett., 17: 987-9(Oct. 24, 1966).

The nuclear ferromagnetic resonance of $^{60}Co$ in Fe was detected by observing the effect of a rf field on the angular distribution of the $\gamma$ radiation emitted by polarized $^{60}Co$ nuclei at temperatures of about 0.03°K. The experimental technique and results are outlined. (M.O.W.)

**2331** THE EFFECT OF CRYSTALLINITY AND BOMBARDMENT DOSE ON THE PENETRATION OF 40-keV XENON IONS IN IONIC CRYSTALS AND CERAMICS. Whitton, J. L.; Matzke, H. J. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys., 44: 2905-14(Nov. 1966). (AECL-2809).

The range and depth distributions of 40-keV xenon ions in single crystals of NaCl, KBr, MgO, $SiO_2$ ($\alpha$ quartz), in sintered $UO_2$, and in fused silica, were measured by the sectioning techniques of vibratory polishing and chemical dissolution. Channeling is observed in the single crystals when the ⟨100⟩ is oriented parallel to the incident beam of the ions. This effect is similar to that previously reported for some metal single crystals. High bombardment doses produce a factor of 2–5 decrease in penetration depth in MgO and $SiO_2$, materials which are known to be damaged by ion bombardment. This decrease is smaller in materials that do not show gross ion bombardment damage, such as NaCl, KBr, and $UO_2$. Thus, the study of ranges is shown to be another means of detecting gross radiation damage. (auth)

**2332** RECOVERY OF PURE AND ALLOYED ALUMINUM IN STAGES I AND II AFTER 2-Mev ELECTRON IRRADIATION. Snead, Clarence Lewis Jr. Chapel Hill, N. C., Univ. of North Carolina, 1965. 82p.

Thesis.

Pure (6N) aluminum and dilute alloys of aluminum were irradiated near helium temperature with 2-MeV electrons and the annealing of stages I and II was studied. Five recovery substages are resolved in stage I with the lowest two ascribed to ⟨110⟩ close pairs and I-C to ⟨110⟩ migration. The addition of 0.3 at. % of Zn, Cu, and Ge suppresses recovery as measured by percent of total recovery throughout stage I but enhances the recovery in stage I as measured by resistivity change. This is true since on the average the damage rates are about 46% higher in the alloys than in the pure sample. Stage II is quite impurity-sensitive but is present in the pure aluminum as evidenced by two annealing peaks. The enhancement of damage is attributed to a Leibfried-type mechanism active at impurity sites. The results fit the framework of the two-interstitial model with few reservations. (Dissertation Abstr.)

**2333** LENGTH CHANGES IN ELECTRON-IRRADIATED GERMANIUM. North, James Clayton. Lafayette, Ind., Purdue Univ., 1965. 133p.

Thesis.

Simultaneous length change and conductivity measurements of n-type, p-type, and high-purity germanium single crystals were made as a function of irradiation by 4.5-MeV electrons at liquid-helium and liquid-nitrogen temperatures and subsequent isochronal annealing. Changes in length of the samples produced changes in the spacing of a system of parallel plate capacitors, and these capacitors were compared with a standard capacitor by means of an ac ratio bridge. The sensitivity and long term stability of the system were such that changes in length on the order of 0.1 angstroms were detectable. It is believed that an electronic volume effect has been observed for the first time in a radiation damage experiment. Degenerate n-type material was found to contract during irradiation at both liquid-helium and liquid-nitrogen temperatures. The specific length change was $\Delta L/L = -9.6 \times 10^{-24}$ per incident electron/cm$^2$ at liquid-helium temperature. This observed contraction is interpreted to mean that the contraction due to the electronic volume effect is larger than the expansion of the atomic effect. Length and conductivity annealing peaks were observed at both 35° and 65°K during isochronal annealing. Length changes in degenerate p-type material were at least an order of magnitude smaller than in n-type, which confirms the belief that p-type is much more radiation-resistant than n-type. The p-type sample was observed to expand slightly at liquid-nitrogen temperature. It is believed that the expansions of the atomic effect are larger than the contractions of any electronic effect present. When p-type germanium is irradiated at liquid-nitrogen temperature, a metastable electron trap is formed within the forbidden gap. Shifting electrons from the valence band to this metastable level produced almost no change in length in the sample. Irradiation of a high-purity sample at either liquid-helium or liquid-nitrogen temperature produced a very large initial expansion, which approached saturation with flux. The initial expansion at liquid-helium temperature of $\Delta L/L = +78. \times 10^{-24}$ per incident electron/cm$^2$ is nearly an order of magnitude larger than any effect observed in either n- or p-type material. (TSS)

**2334** THE STUDY OF IRRADIATION-INDUCED DEFECTS IN TUNGSTEN THROUGH EFFECTS ON MECHANICAL PROPERTIES. DiCarlo, James Anthony. Pittsburgh, Univ. of Pittsburgh, 1965. 240p.

Thesis.

Polycrystalline wires and single crystal rods of tungsten were irradiated at 80°K with 13-MeV deuterons accelerated in the University of Pittsburgh cyclotron. Measurements were made of internal friction and the dynamic Young's modulus by electrostatically driving a cantilevered sample in its two lowest flexural resonant modes. During irradiation, apparent pinning of dislocations reduced the friction and increased the modulus. Prolonged irradiation produced a decrease in the modulus, which was linear in flux. The rate of decrease, which varied with pre-irradiation sample treatment, appears to depend upon the net rate of vacancy production. On warmup to 300°K two transient internal friction peaks, I and II, were consistently found in the friction-versus-temperature curve for the polycrystalline wires (2000 ppM impurity concentration). At one kilocycle, I was observed at 100°K and II at 190°K. The temperature dependence and shape of each peak indicate the existence of a thermally activated atomic jump process. For peaks I and II respectively: activation energies are $0.17 \pm 0.03$ and $0.40 \pm 0.04$ eV, and attempt frequencies are $10^{12.6\pm1}$ sec$^{-1}$ and $10^{14.3\pm1.0}$ sec$^{-1}$. The isothermal anneal of peak II showed first order kinetics with an activation energy of $0.45 \pm 0.05$ eV. About $10^9$ atomic jumps was the average lifetime of each peak. Dependence on deuteron flux showed that both peak heights saturated at approximately 500 ppM displaced atom concentration. Irradiation of high-purity single crystals (10 ppM impurity concentration), both unworked and heavily cold-worked, produced neither of the peaks. It is believed that the internal friction peaks are caused by the stress-induced ordering of irradiation-induced interstitial atoms trapped at impurities. (Dissertation Abstr.)

**2335** EFFECT OF THERMAL NEUTRON INDUCED DEFECTS ON THE OPTICAL PROPERTIES OF CADMIUM TELLURIDE. Barnes, C.; Kikuchi, C. (Univ. of Michigan, Ann Arbor). 17p. (CONF-660705-4). ORAU. Gmelin, AED-CONF-66-222-4.

From IEEE Annual Conference, Palo Alto, Calif.

The properties of thermal neutron induced recoil defects in CdTe were studied by measuring fluorescence and transmission as a function of wavelength before and after successive irradiations. (M.H.R.)

**2336** INFLUENCE OF MICROSTRUCTURE ON DIELECTRIC AND FERROELECTRIC PROPERTIES. Jaffe, Bernard (Clevite Corp., Cleveland). 16p. (CONF-660619-2). ORAU. Gmelin, AED-CONF-66-204-1.

From 3rd International Materials Symposium on Ceramic Microstructure, Berkeley, Calif.

Ferroelectricity and domain structure in oxide crystals are discussed. The possible effects of microstructure on dielectric properties are considered for $Pb(Ti,Zr)O_3$, $BaTiO_3$, and other ceramics. It is concluded that the texture influencing the behavior of a ferroelectric ceramic is the domain texture, and that the microstructure has an appreciable effect only when very little recrystallization has taken place with increasing heat work. (D.L.C.)

## Theoretical Physics

*Refer also to abstract 2009.*

**2337** (NP-16362) COMPUTATIONS IN THE THEORETICAL PHYSICS: GEOMAGNETISM, TOPOLOGY OF VECTOR FIELDS, MAXWELL-BOLTZMANN DIFFERENTIAL EQUATION, MOTIONS OF CORE FLUID, DYNAMO ACTION IN TENUOUS FLUIDS. McDonald, Keith L. (Utah Univ., Salt Lake City). Feb. 1, 1966. 130p. Bull. No. 138, Utah Eng. Expt. Station.

A theoretical investigation of several disjoint subjects related to hydromagnetism and electrodynamics was made. The section on geomagnetism contains rather extensive computations relating to the magnetic topography of the core–mantle interface and to several rms observational quantities. The topology of vector fields is considered and confluent vector singular points are classified for confluence processes involving only two linear fields. The Maxwell–Boltzmann differential equation is treated and a new

equation of change is derived corresponding to rotational degrees of freedom. One section is devoted to establishing the negligible effects of mechanical fluid viscosity in the earth's core. The adiabatic laws of expansion are derived for ultracompressed fluids and application is made to the earth's core by the method of discrete juxtaposition. Finally, dynamo action of highly compressible fluids is applied to stellar bodies. (auth)

**2338** (NP-16369) LECTURES ON RELATIVITY THEORY. Ray, John (Illinois Univ., Urbana. Coordinated Science Lab.). Aug. 1966. Contract DA-28-043-AMC-00073(E). 158p. (R-311).

Both the special and general theories of relativity are covered. The coverage of the special theory is fairly complete while that of the general theory is somewhat abbreviated. The lectures on the general theory stopped with the derivation of the Schwarzschild solution and a discussion of the linear theory. (auth)

**2339** HAMILTON'S PRINCIPLE FROM A QUANTAL POINT OF VIEW. Fujiwara, Izuru (Norwegian Inst. of Tech., Trondheim). Ark. Fys. Seminar Trondheim, No. 5, 16p.(1966).

From the standpoint that classical mechanics should represent a limiting case of quantum mechanics in the limit of quantum of action tending to zero, Hamilton's principle of stationary action is reexamined. Here the action denotes the time integral of the Lagrangian over a finite interval of time. It is concluded that the time interval should be infinitely long ranging from infinite past to infinite future, and moreover that the ordinary variational calculus is to be simplified to the functional differential calculus in order to afford an adequate formulation of Hamilton's principle. (auth)

**2340** WHAT ARE SPINORS? Rindler, W. (Southwest Center for Advanced Studies, Dallas). Contract N00014-66-C0169-A03. Amer. J. Phys., 34: 937-42(Oct. 1966).

Spinors have in recent years become an important mathematical tool in special and general relativity. After a general review of the status of physical laws, it is shown why spinors are the "basic building bricks" of any Lorentz invariant law. The properties of spinors are briefly discussed and it is shown why it sometimes pays to translate a tensor problem into spinor language, solve it therein, and finally translate back. (auth)

**2341** WAVE-MECHANICAL DESCRIPTION OF THE ELECTRON IN A HOMOGENEOUS TIME-VARYING ELECTRIC FIELD. Kohler, Robert H. (Rutgers, The State Univ., Newark, N. J.). Phys. Rev., 151: 165-9(Nov. 4, 1966).

The nonrelativistic electron driven by a classical homogeneous time-varying field is given an exact wave-mechanical treatment. The problem is formulated and solved in two separate reference frames. One is a frame that accelerates like a classical electron that is in the same field, and here the wave mechanics is formally that of a free electron. The second frame is an inertial frame, and here the time-development operator is given two explicit forms. States of sharp but time-dependent momentum are found. Wave functions in both momentum and configuration spaces are given. Packets that move in the manner of a classical electron are produced conveniently. The physical interpretation of the wave-mechanical description is given graphical illustration in a phase-space plot. The circumstances where a purely classical description suffices are elucidated. It is shown that the wave-mechanical analysis based on a homogeneous electric field can be suitably applied to several physical situations as a good approximation. One situation is the electron in a propagating classical electromagnetic wave of arbitrary frequency. Another situation is an electron in transit through the fields in a microwave cavity. The wave mechanics of an electron plasma in a homogeneous time-dependent electric field is treated separately and yields some tangible information. (auth)

**2342** NOTE ON THE GRAVITATIONAL INTERACTION. Kimura, Toshiei (Hiroshima Univ.). Progr. Theoret. Phys. (Kyoto), 36: 394-409(Aug. 1966).

The question whether the gravitational interactions can be introduced consistently within the framework of the Lagrangian formalism in Minkowski space is investigated. When the starting source term is the energy–momentum tensor derived from the free Lagrangian, the gravitational self-interaction and the interactions coupled with the matter fields can be obtained up to a higher-order approximation. On the other hand, when the primary gravitational interactions contain the general anomalous form factors proposed by Hiida and Yamaguchi, one cannot find a consistent-interaction Lagrangian even to the second-order approximation unless the formalism of the free gravitational field is modified. These features are also viewed from the standpoint of covariance in Einstein's general relativity. (auth)

**2343** TEST OF GENERAL RELATIVITY BY MEANS OF SUPERCONDUCTORS. Papini, G. (Univ. of Saskatchewan Regina Campus, Sask., Can.). Phys. Lett., 23: 418-19(Nov. 14, 1966).

An experiment to measure the Lense–Thirring field of the earth using a loop of superconducting wire is proposed. (auth)

**2344** THE EFFECT OF TERMS QUADRATIC IN THE RIEMANN TENSOR UPON THE FIELD EQUATIONS OF GENERAL RELATIVITY. Hill, Thomas Waddell. Chapel Hill, N. C., Univ. of North Carolina, 1965. 41p.

Thesis.

The effect of introducing perturbation terms proportional to the square of the Riemann tensor into the action functional which leads to the field equations is examined. The coupling constant is taken to be of the order of $l^2 = 8Gh/c^3$, which is approximately $(10^{-32}\ \text{cm})^2$ in cgs units. The theory is applied to the solutions for the closed, isotropic model of the universe and for the spherically symmetric field, with the intent of removing the singular behavior which occurs in both cases for certain regions of space-time. The method consists of obtaining initial values for the solutions in regions where the perturbation term has a small absolute value and then using an appropriate differencing scheme on the digital computer to find the corresponding solutions in the region of interest. This approach removes the "Schwarzschild singularity," but it does not rid the spherically symmetric field of the singularity at the origin. The most successful aspect of the theory is that the introduction of an $R^2 \log (R^2)$ term, where R is the Riemann scalar, gives a solution for the cosmological model which is well-behaved at the time origin. (Dissertation Abstracts)

**2345** DIFFERENTIAL SPACE, QUANTUM SYSTEMS, AND PREDICTION. Wiener, Norbert; Siegel, Armand; Rankin, Bayard; Martin, William Ted. Cambridge, Mass., Massachusetts Institute of Technology Press, 1966. 184p. $7.50

A review is given of historical and formal developments of differential space, quantum systems, and prediction theory. Included are the theory and construction of Brownian motion, integration in differential space, prediction of single series stationary processes, the development of quantum concepts on the basis of differential space, multiple prediction using the successive projection technique, the Fourier–Hermite development of nonlinear functionals, and the postulational basis for measure–theoretic probability theory. A verification of the conjecture that ensembles of completely described systems obeying a postulated dynamics can be so constructed as to have the same statistical properties as those expressed by a given quantum-mechanical wave is given by means of differential space theory. (J.F.P.)

# PHYSICS (HIGH ENERGY)

## Particle Interactions and Properties (Experimental)

### *Electromagnetic*

**2346** (NYO-1984-10) HIGH ENERGY PHYSICS AT TUFTS UNIVERSITY. Progress Report, September 1966. Knipp, J. K. (Tufts Univ., Medford, Mass.). Contract AT(30-1)-1984. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A progress report is presented on the research activities of the theory; nuclear emulsion, bubble chamber analysis, high energy photons, and nuclear groups at Tufts University for September, 1966. Topics emphasized are study of T violation and form factors in $K_{\mu 3}$ decay, polarization in neutral pion photoproduction, production of polarized photon beams, automatic spark-chamber film reader, and pion lifetime measurements. (B.G.D.)

**2347** PHOTOPRODUCTION OF SINGLE POSITIVE PIONS BETWEEN 1.2 AND 3 GeV. Buschhorn, G.; Carroll, J.; Eandi, R. D.; Heide, P.; Heubner, R.; Kern, W.; Koetz, U.; Schmueser, P.; Skronn, H. J. (Deutsches Elektronen Synchrotron, Hamburg. Univ., Hamburg). Phys. Rev. Lett., 17: 1027-30(Nov. 7, 1966).

Differential cross sections for the reaction $\gamma + p \rightarrow n + \pi^+$ are presented for incident photon energies between 1.2 and 3 GeV and pion center-of-mass production angles of 15 to 50 deg. (auth)

**2348** ASYMMETRY RATIOS IN THE PHOTOPRODUCTION OF $\pi^+$ BY LINEARLY POLARIZED $\gamma$-RAYS IN THE ENERGY RANGE 200-400 MeV. Gorenstein, P. (CNEN, Frascati, Italy); Grilli, M.; Soso, F.; Spillantini, P.; Nigro, M.; Schiavuta, E.; Valente, V. Phys. Lett., 23: 394-6(Nov. 7, 1966).

The asymmetry ratio for the process $\gamma + p \rightarrow n + \pi^+$ by linearly polarized $\gamma$ rays are reported for $E_\gamma$ = 200 to 400 MeV and for $\theta$ (production angle of $\pi$ in the cms system) = 90°. The experimental results are compared with some recent theoretical predictions. (auth)

**2349** SIGN OF THE $K_L - K_S$ MASS DIFFERENCE. Canter, J. (Carnegie Inst. of Tech., Pittsburgh); Cho, Y.; Engler, A.; Fisk, H. E.; Kraemer, R. W.; Meltzer, C. M.; Hill, D. G.; Robinson, D. K.; Sakitt, M. Phys. Rev. Lett., 17: 942-4(Oct. 24, 1966). (BNL-10607)

The sign of the $(K_L^0 - K_S^0)$ mass difference was measured by studying the time distribution of scattered neutral K mesons, using $K^0$'s from the reaction $K^+ + d \rightarrow K^0 + p + p$. It was found that $m(K_L) > m(K_S)$. (auth)

**2350** EXPERIMENTAL INVESTIGATION OF THE $K^0 \rightarrow \pi^+\pi^-\gamma$ DECAY. Bellotti, E. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan); Pullia, A.; Baldo-Ceolin, M.; Calimani, E.; Ciampolillo, S.; Huzita, H.; Mattioli, F.; Sconza, A. Nuovo Cimento (10), 45A: 737-9(Oct. 1, 1966).

The results obtained from 27 $K^0$ decays in the mode $\pi^+\pi^-\gamma$ observed in a heavy-liquid bubble chamber are reported. No evidence was found for the $K_1^0$ radiative decay: the limit obtained was $\Gamma_L$ $(\pi^+\pi^-\gamma) < 10^5\ S^{-1}$ with 60% confidence. The decay rate and the energy distributions of the decay products were found in good agreement with the hypothesis that the $K_S^0 \rightarrow \pi^+\pi^-\gamma$ decay goes through the inner bremsstrahlung only. (L.B.S.)

**2351** PHOTONEUTRON PRODUCTION FROM THE PROTON AT HIGH ENERGY. Costa, S. (Univ., Turin); Ferroni, S.; Gracco, V. G.; Silva, E.; Schaerf, C. Nuovo Cimento (10), 45A: 696-705(Oct. 1, 1966).

The total neutron yield from the $(\gamma,n)$ reaction in hydrogen was measured as a function of the energy of the primary electron using the bremsstrahlung beam from the Orsay Linear Electron Accelerator. The yield was interpreted as a contribution from single and double pion photoproduction in hydrogen. Close to threshold the results are consistent with the theoretical prediction of CGLN for single pion photoproduction. In the energy region (250 to 450) MeV the results are consistent with the experimentally measured values of the total positive-pion photoproduction cross-section. At higher energies the results indicate a higher yield than previously anticipated for double pion photoproduction in the particular channel $\gamma + p \rightarrow n + \pi^+ + \pi^0$. (auth)

**2352** PRODUCTION OF CIRCULAR POLARIZED $\gamma$-RAYS BY COHERENT BREMSSTRAHLUNG OF LONGITUDINAL POLARIZED ELECTRONS. Neumcke, B. (Univ., Munich). Phys. Lett., 23: 382-4(Nov. 7, 1966).

The coherent bremsstrahlung of longitudinal polarized extreme relativistic electrons is calculated. In this way $\gamma$ rays in the GeV-region with a high degree of circular polarization and a great intensity are obtainable. Conversely longitudinal polarization of electrons may be measured. (auth)

**2353** INVESTIGATION OF SHOWERS PRODUCED BY 45, 130, 230, AND 330 MeV ELECTRONS IN LEAD. Zaimidoroga, O. A.; Prokoshkin, Yu. D.; Tsupko-Sitnikov, V. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 51: 749-59(Sept. 1966). (In Russian).

Showers produced in lead by 45 ± 5, 130 ± 10, 230 ± 15, and 330 ± 20 MeV electrons are studied with a cloud chamber. Cascade curves and angular distributions of the secondary electrons are obtained and the integral shower paths are determined. (auth)

**2354** ELASTIC SCATTERING OF HIGH-ENERGY ELECTRONS FROM DEUTERIUM. Erickson, Edwin Francis. Stanford, Calif., Stanford Univ., 1966. 257p.

Thesis.

The cross section for elastic scattering of electrons from deuterons has been measured at five values of the squared four-momentum transfer, t, from $5.62\ F^{-2} < -t < 16.8\ F^{-2}$ by detecting the recoil deuterons. Absolute values of the deuteron cross sections were obtained by normalizing the deuteron data to measurements of elastic electron-proton scattering, a process for which the cross section is known from independent studies. A review of theories of elastic electron-deuteron scattering is presented. Some minor corrections to the theory of Jankus are pointed out. The predictions of the nonrelativistic impulse approximation and various corrections thereto are given and discussed. The predictions were calculated for nine different deuteron models assuming both $F_{1n} = 0$, and $G_{En} = 0$. Corrections considered are those implied by simple dispersion theory arguments, first order relativistic corrections arrived at by improving the impulse approximation, and mesonic exchange-current corrections. The dispersion theory corrections are shown to be smaller than originally anticipated by Jones. The relativistic corrections considered are found to be negligible except for a term calculated by Gourdin which begins to contribute more than about ten percent to the magnetic scattering predicted by the impulse approximation for $-t > 5\ F^{-2}$. Evaluation of Adler's $\rho$-$\pi$-$\gamma$ exchange current corrections shows that they predict a ten percent increase in the magnetic scattering for $-t \sim 1.5\ F^{-2}$, and in the electric (charge plus quadrupole) scattering for $-t \sim 12\ F^{-2}$; the exchange contributions increase in importance as $-t$ increases. If the cross section divided by the Mott cross section is written $A(t) + B(t) \tan^2(\theta/2)$, where $\theta$ is the laboratory angle which the scattered electron makes with the incident electron direction, the predictions for A(t) are much more sensitive to the choice of the neutron charge form factor than are those of B(t). However, the uncertainties in the predictions caused by the deuteron model dependence, by the nucleon form factor dependence, and by the variety of extant possible corrections make it difficult to isolate individual effects when comparing the predictions with experimental data. Further theoretical work is indicated. In the experiment reported, the data closely correspond to measurements of A(t), since $\theta$ never exceeded 65°, and B(t) $\lesssim$ 0.1 A(t). The general momentum transfer dependence of the data is predicted by the theory. The theory indicates that the scattering in the vicinity of the two high momentum transfer points is caused by the quadrupole moment in the deuteron. Quadrupole scattering from the deuteron has not been previously observed. Of the predictions evaluated, one employing a Hamada deuteron model, the impulse approximation with $G_{En} = 0$, and the $\rho$-$\pi$-$\gamma$ exchange corrections, provides a satisfactory fit to the data. (Dissertation Abstr)

**2355** INELASTIC INTERACTIONS OF THE COSMIC-RAY MUONS IN A THICK LEAD TARGET. Lasky, Paul Howard. Seattle, Univ. of Washington, 1965. 129p.

Thesis.

An experiment was performed in an attempt to detect events in which high-energy cosmic muons disappear in a thick absorber by processes other than the normal decay mode, and in particular, if such processes do occur, to determine whether there is a dissymmetry in behavior between the two signs of charge. No conclusive evidence was found for the occurrence of "true" disappearances, and the behavior of the particles was entirely symmetrical with regard to sign, within experimental error. Such disappearances as were actually observed are interpretable in terms of inelastic scattering at large four momentum transfers, and ordinary multiple coulomb scattering. The target was 11" of lead with a small geiger tray placed in a 1" gap in the middle. One cloud chamber 12" × 14" × 5" was above the target, a similar one below and a field of 11 kilogauss filled the whole volume. A lead filter 24" thick was above the top chamber. Other

counter trays in coincidence or anticoincidence defined the events. In the first two of four runs particles were selected which traversed the top chamber and produced a pulse in the middle tray, but were not observed in the bottom chamber. These events were defined as "disappearances" ("D" events). In the second two runs no anti-coincidence was required; particles were generally observed traversing both chambers, but a large pulse was required in a mid-target proportional counter which replaced the geiger tray of the first two runs. Such events were called high-pulse (HP) events. These runs were also searched for "D" events. A total of 85 "D" events were found in all runs, 44 positive muons and 41 negative muons. A comparison of their momentum spectra reveals no statistically meaningful difference. The disappearance momentum spectrum, after correction for events in which muons are multiple scattered far enough laterally to miss the bottom chamber, was then replotted as a cross section per nucleon. The best fit to the data gave a momentum dependence for the cross section of approximately 0.38 $\log_e P$. However, within errors, the dependence was also in agreement with the approximately linear dependence on P predicted by the Daiyasu et al. theory for the production of pions in mu-proton collisions. Several possible mechanisms for disappearances are considered, and it is concluded that inelastic muon-proton collisions with pion production accounts for about 97% of the observed events. The momentum losses of 206 muons in the high-pulse runs were in substantial agreement with the work of Neddermeyer and Curtis. Moreover, since the scattering angles of these events were measured, the four momentum transfer for each event was computed. The differential squared four momentum transfer (t) spectrum of these events is in agreement with the theory for inelastic muon-proton pion production when an inelastic proton form factor equal to the elastic proton form factor is used. Alternative explanations of the t spectrum are in wide disagreement with the histogram. Eleven events having t values over 1 $(BeV/c)^2$ were observed; the largest transfer observed was t = 3.2 $(BeV/c)^2$. Events are also plotted in the momentum loss-four momentum transfer plane. In the large t region the cross section for high pulse events is shown to be appreciable only when the momentum loss and four momentum transfer are both large. No correlation was observed for t values less than 0.6 $(BeV/c)^2$. Below the kinematic limit for pion production, a large excess of positive events is observed; no such charge asymmetry is observed above the limit. Insensitivity of the results due to alteration of the lead shield above the apparatus indicates that proton contamination was negligible in all four runs. (Dissertation Abstr.)

## Weak

*Refer also to abstracts 2010 and 2439.*

**2356** (JINR-P-2855) ENERGETICHESKIE SPEKTRY I UGLOVYE KORRELYATSII CHASTITS V $K^0_{e3}$-RASPADE. (Energy Spectra and Angular Correlations of Particles in $K^0_{e3}$-Decay). Kulyukina, L. A.; Mestvirishvili, A. N.; Nyagu, D.; Petrov, N. I.; Rusakov, V. A.; Wu, Tsun-fan (Joint Inst. for Nuclear Research Dubna (USSR). Lab. of Nuclear Problems). 1966. 11p. Dep. mn.

On the basis of the identified 394 $K^0_{e3}$ decays the electron spectra and the distributions of the angles of electron and $\pi$-meson divergence are obtained, when $\pi$-mesons are fixed according to the energy in the ranges $\Delta E$ = 231-270 MeV and $\Delta E$ = 244-270 MeV. The obtained, distributions are well described by vector interactions only. Scalar and tensor variants with the certainty above 99.9% are excluded as a single variant of interaction. Their possible contribution to the interaction is 10-12%. By the experiment no dependence of $g_v$ form-factor on electron energy is found out. (auth)

**2357** EXPERIMENT ON THE SIGN AND MAGNITUDE OF THE $K^0_L - K^0_S$ MASS DIFFERENCE. Jovanovich, J. V. (Brookhaven National Lab., Upton, N. Y. Oxford Univ. Univ. of Manitoba, Winnipeg); Fujii, T.; Turkot, F.; Zorn, G. T.; Deutsch, M. Phys. Rev. Lett., 17: 1075-8(Nov. 14, 1966).

On the basis of a definite result from a Kobzarev-Okun' experiment on coherent regeneration, and an optical model calculation, evidence that the $K^0_L$ is heavier then the $K^0_S$ is presented. (auth)

**2358** PRECISE MEASUREMENT OF THE PARAMETER $\delta$ GOVERNING THE DECAY SPECTRUM OF POLARIZED MUONS. Ehrlich, R. D.; Fryberger, D.; Jensen, D. A.; Nissim-Sabat, C.; Sherwood, B. A.; Telegdi, V. L. (Univ. of Chicago). Contract Nonr 2121(25). Phys. Rev. Lett., 17: 1118-21(Nov. 21, 1966).

A precision measurement of the energy dependence of the asymmetry of the decay of the positive muon was made with a wire spark-chamber spectrometer of large momentum acceptance. As an average of runs at different fields and with different targets it was found that $\delta = 0.758 \pm 0.010$, in agreement with the two-component neutrino theory. (auth)

**2359** $\Sigma^+$ DECAY PARAMETERS. Berley, D. (Brookhaven National Lab., Upton, N. Y.); Herzbach, S.; Kofler, R.; Yamamoto, S.; Heintzelman, W.; Schiff, M.; Thompson, J.; Willis, W. Phys. Rev. Lett., 17: 1071-4(Nov. 14, 1966).

The decay parameters of $\Sigma^+ \rightarrow n + \pi^+$ were measured. The decay occurs through the p-wave channel: $\alpha_+$ is small ($+0.047 \pm 0.07$); the likelihood ratio $(\gamma = -1)/(\gamma = +1)$ is $2 \times 10^4$. Defining $\varphi$ by $\beta_+ = \sin\varphi$, $\gamma_+ = \cos\varphi$, $\varphi = 180^\circ \pm 30^\circ$ is found. The result confirms the prediction that $s(\Sigma^+_+) = 0$. It also excludes a violation of T through a large "imaginary" s amplitude. (auth)

**2360** ANGULAR DISTRIBUTION OF POSITRONS OF $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ DECAY IN 140 kG MAGNETIC FIELD. Akhmonov, V. V.; Gurevich, I. I.; Dobretsov, Yu, P.; Makar'ina, L. A.; Nikol'skii, B. A.; Sokolov, B. V.; Surkova, L. V.; Khakimov, S. Kh.; Shestakov, V. D. pp 30-40 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The decay $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ was investigated under a magnetic field of 146 ± 1.5 kG. The angular distribution of the positron was measured and the experimental results were compared to the values given by the V-A interaction theory. It was concluded that the V-A interaction theory is a workable model for explaining the $\pi^+$ decay. (G.O.Y.)

**2361** MEASUREMENT OF THE RELATIVE DECAY RATES OF THE $K^0_2$ MESON INTO ITS PRINCIPAL CHARGED MODES. Pepin, Mark. Helv. Phys. Acta, 39: 523-55(1966).

An experiment to measure the relative decay rates of the $K^0_2$ meson was performed with the help of a large magnet cloud chamber placed in a nearly monochromatic beam of $K^0_2$ mesons. As the kinematic analysis did not allow a large fraction of the events to be identified, Monte Carlo events were generated and used to study the recognition probabilities of events belonging to the different $K^0_2$ decay modes. The comparison of the Monte Carlo events to the real decays permitted the relative decay rates of the $K^0_2$ meson into its principal charged modes to be evaluated via a maximum likelihood fit. The values obtained are compared to the predictions of the $|\Delta I| = \frac{1}{2}$ rule. (auth)

**2362** A MEASUREMENT OF THE MAGNITUDE OF THE MASS DIFFERENCE $M_{K^0_S} - M_{K^0_L}$. Baldo-Ceolin, M.; Calimani, F.; Ciampolillo, S.; Fry, W. F.; Huzita, H.; Leardini, M.; Miari, G. (Univ., Padua. Istituto Nazionale di Fisica Nucleare, Padua). Nuovo Cimento (10), 45A: 733-6(Oct. 1, 1966).

A measurement is reported of the mass difference $M_{K^0_S} - M_{K^0_L}$ using the strangeness oscillation of an initially pure $K^0$ state. $\bar{K}^0$'s were produced by the charge exchange of 800 MeV/c $K^+$ mesons in a heavy-liquid bubble chamber filled with equal volume of propane and freon. The analysis of the distribution of events in the chamber is discussed. The best value obtained for $|\Delta m|$ for constant $\bar{K}^0$ cross section was 0.42 $(\hbar/c^2)$ $10^{10}$g. (L.B.S.)

**2363** INELASTIC MUON INTERACTIONS AT 2.5 BeV. Bachhuber, Carl Gregory. Seattle, Univ. of Washington, 1965. 85p.

Thesis.

Nuclear photographic emulsions were exposed to a 2.5 BeV muon beam and 37,000 meters of track were examined for nuclear interactions of the muon (stars). The angular differential cross section was found to be in agreement with a simple theory which relates electroproduction to photoproduction cross sections. This theory makes two approximations: the effect of the longitudinal component of the electric field of virtual photons is omitted, and the transverse component of the electric field of virtual photons is assumed to be as effective as that of free photons. It was found that the scattering angles of the muons at stars (nuclear interactions) were typically smaller than those reported for emulsions exposed to cosmic rays underground. (Dissertation Abstr)

**2364** THE THREE-BODY DECAYS OF THE $K^0$ MESON AND THE $\Delta S = \Delta Q$ RULE. Kirsch, Lawrence Edward. New Brunswick, N. J., Rutgers–The State Univ. of New Jersey, 1966. 58p.

Thesis.

The three body decays of $K^0$ mesons have been used to test the validity of the $\Delta S = \Delta Q$ and $|\Delta I| = \frac{1}{2}$ selection rules. More than 5000 $K^0$ mesons produced in the annihilation of stopping antiprotons in the 30'' Columbia-Brookhaven liquid hydrogen bubble chamber, were analyzed to extract 50 three body decays. The $\Delta S = \Delta Q$ rule predicts the ratio of the leptonic decay rates $\alpha = K^0_1 \rightarrow \pi^\pm \mu^\mp \nu + \pi^\pm e^\mp \nu / K^0_2 \rightarrow \pi^\pm \mu^\mp \nu + \pi^\pm e^\mp \nu$ to be one. The present experiment obtains $\alpha = 0.90^{+1.25}_{-0.80}$. The leptonic decay rate for $K^0_2$ is found to be $(11.1^{+2.0}_{-1.9}) \times 10^6$ sec.$^{-1}$ in agreement with the prediction of the leptonic $|\Delta I| = \frac{1}{2}$ rule. The rate for the decay $K^0_2 \rightarrow \pi^+ \pi^- \pi^0$ is found to be $(2.08 \pm 1.02) \times 10^6$ sec.$^{-1}$ in agreement with the $|\Delta I| = \frac{1}{2}$ rule. (Dissertation Abstr)

## Strong (Baryon-Induced)

**2365** (PPAD-600-F) ISOBAR PRODUCTION MECHANISMS IN PROTON–PROTON COLLISIONS AT 5 GeV/c. Colleraine, A. P. (Princeton Univ., N. J. Palmer Physical Lab. Princeton–Pennsylvania Accelerator, Princeton, N. J.). Aug. 1, 1966. Contract AT(30-1)-2137. 161p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Thesis.

Approximately 7500 4 prong proton-proton collisions at 5 GeV/c have been studied using the BNL 80'' hydrogen bubble chamber. The three principal reactions with their cross sections were determined to be: $p + p \rightarrow p + p + \pi^+ + \pi^-$, $p + p \rightarrow p + p + \pi^+ + \pi^- + \pi^0$, $p + p \rightarrow p + n + \pi^+ + \pi^+ + \pi^-$ with cross sections of (2.96 ± 0.12) mb., (1.76 ± 0.07) mb., (2.19 ± 0.09) mb. respectively. In each reaction both single and double N* production occurs and the decay angular distributions and density matrix elements were calculated whenever possible. These parameters indicate that pseudoscalar exchange appears to be dominant at low momentum transfers and that for higher values of momentum transfer absorptive effects become important. The formation of the eta and the omega meson resonances are observed in the second reaction but in none of the reactions is any significant rho meson production found to occur. (auth)

**2366** PROTON–PROTON ELASTIC SCATTERING AT 90 DEG AND STRUCTURE WITHIN THE PROTON. Akerlof, C. W. (Univ. of Michigan, Ann Arbor); Hieber, R. H.; Krisch, A. D.; Edwards, K. W.; Ratner, L. G.; Ruddick, K. Phys. Rev. Lett., 17: 1105-9(Nov. 21, 1966).

A series of measurements of the proton-proton elastic differential cross section for a 90° center-of-mass scattering angle is reported. The incident proton momenta varied from 5.0 to 13.4 GeV/c in steps of 200 MeV/c or less. Four conclusions are drawn. The conclusions are that there is a difference between the π-nucleon and the nucleon-nucleon systems, that the statistical model does not appear to be useful in the momentum range 5.0 to 13.4 GeV/c, if the trend of the data continues it would indicate that the scattering amplitude is not analytic and bounded. Also the sizes of the inner and outer regions of the proton are found. (auth)

**2367** SEARCH FOR QUARKS IN COSMIC RAYS. Lamb, R. C.; Lundy, R. A.; Novey, T. B.; Yovanovitch, D. D. (Argonne National Lab., Ill.). Phys. Rev. Lett., 17: 1068-70(Nov. 14, 1966).

From a search for fractionally charged particles (quarks) in cosmic rays upper limits were found for particles with either a $\frac{1}{3}$ or $\frac{2}{3}$ charge. These limits are lower than previous limits. Measurements were made of the ionization of particles traversing a counter telescope, and histograms of events satisfying the correlation tests are shown as a function of the average energy loss. (J.F.P.)

**2368** EFFECTIVE IDENTIFICATION OF CHARGED PARTICLES BY MEANS OF δ ELECTRONS AT $1.5 \leq p\beta c \leq 2.5$ GeV. Boos, E. G.; Zaitsev, K. G.; Temiraliev, T. Izv. Akad. Nauk Kaz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 56-60(Apr.-June 1966). (In Russian).

A method for identifying charged particles by means of δ electrons at $1.5 \leq p\beta c \leq 2.5$ BeV was developed. The method was used for identifying the two- and three-pronged pN events produced by 19.8 BeV/c protons in an Ilford G-5 emulsion. (G.O.Y.)

**2369** SEARCH FOR FLUCTUATIONS IN THE ANGULAR DISTRIBUTION OF PROTON-PROTON SCATTERING AT 16.9 GEV/C. Allaby, J. V.; Bellettini, G.; Cocconi, G.; Diddens, A. N.; Good, M. L.; Matthiae, G.; Sacharidis, E. J.; Silverman, A.; Wetherell, A. M. (CERN, Geneva). Phys. Lett., 23: 389-93(Nov. 7, 1966).

Measurements of the angular distribution of proton-proton elastic scattering at 16.9 GeV/c from 67 to 90° in the cms are presented. The data are fitted by an exponential in the transverse momentum, $\exp-(p \sin\theta/b)$ with b = (225 ± 4) MeV/c and do not display the characteristic fluctuation predicted by Ericson's statistical model. (auth)

**2370** PION PRODUCTION AND ELASTIC SCATTERING IN ANTIPROTON-PROTON COLLISIONS AT 7 BEV/C. Johnson III, Joseph Andrew. New Haven, Yale Univ., 1965. 174p.

Thesis.

Seven thousand exposures of the 80'' Hydrogen Bubbie Chamber to a 7 BeV/c antiproton beam were studied for nonstrange $\bar{p}$-p interactions. The total cross section was measured to be 58.7 ± 2.8 mb, in good agreement with the value 57.8 ± 1.0 mb obtained in previous experiments using counter techniques. The elastic interaction cross section was found to be 14.2 ± 1.2 mb with an interaction radius of 1.4 ± .1f. The elastic differential cross section is well described for four-momentum transfer $(-t) \leq 0.2$ $(BeV/c)^2$ by the form $d\sigma/dr = Ae^{-bt}$ where b = 13.1 ± 1.1. Single pion production showed 70% πN resonance formation with both $I = \frac{3}{2}$ and $I = \frac{1}{2}$ equally prominent. N*(1238) isobar and anti-isobar formation dominated pion production in four and six pronged interactions; the double isobar formation cross section was found to be 1.2 ± 0.3 mb. Isobar production is observed to be consistent with the predictions of a dominant one particle exchange process. (Dissertation Abstr.)

## Strong (Meson-Induced)

*Refer also to abstract 2477.*

**2371** (CEA-R-2948) UNE ETUDE DE L'INTERACTION $\pi^+$ PROTON A 3,5 Gev/c. (A Study of the $\pi^+$ Proton Interaction at 3.5 Gev/c). Duong, Nhu Hoa (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1966. 79p. In French. Dep. mn.

Thesis. Submitted to Paris Univ., France.

The $\pi^+$ proton interaction leading to two charged outgoing particles has been studied at the incident momentum of 3.2 and 3.5 GeV/c. The pictures were obtained from an exposure of the Brookhaven National Laboratory 20-inch bubble chamber. For the two energies: 1741 events of the reaction $\pi^+ + p \rightarrow \pi^+ + p + \pi^0$, 1100 events of the reaction $\pi^+ + p \rightarrow \pi^+ + \pi^+ + n$ and 4079 events of the reaction $\pi^+ + p \rightarrow \pi^+ + p$ were identified. A study of the exchange mechanism in the $N^*_{33}$ production is discussed. The resonances $N^*_\zeta(1688)$, ρ, η, ω and A1, A2 are observed and discussed. Other results, the elastic interaction and various cross sections are also presented. (auth)

**2372** (CEA-R-3037) QUELQUES PROPRIETES DES REACTIONS A DEUX CORPS DANS LES INTERACTIONS $K^-p$ A 3 Gev/c. (Some General Features of Two Body Reactions in $K^-$-p Interactions at 3 Gev/c). Badier, Jean; Demoulin, Michel; Goldberg, Jacques; (and others) (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). June 1966. 24p. Dep. mn.

The differential and total cross sections of two-body reactions produced in 3 BeV/c $K^-$-proton collisions are presented. Their variation as a function of the baryonic number, strangeness, and isospin of the t and u cross channels is analyzed, as well as some implications of a baryon exchange mechanism. (auth)

**2373** (PPAD-598F) CHARGE EXCHANGE SCATTERING OF $K^+$ MESONS ON $^9$Be AT .970 GeV/c. Gezelter, Joseph (Princeton–Pennsylvania Accelerator, Princeton, N. J.). Aug. 22, 1966. Contract AT(30-1)-2137. 137p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Thesis.

The angular distribution of $K^0$ mesons from the reaction $K^+ + n \rightarrow K^0 + p$ was measured using a .970 GeV/c $K^+$ beam incident on a thin plate spark chamber which contained beryllium targets. The cms angular distribution was obtained after corrections were made for N* production and the geometry of the spark chamber. The method of least squares was used, and six sets of real, I = 0, S and P wave phase shifts were found which were the locations of local minima. I = 1, complex, S and P wave phase shifts and the $K^+ - n$ total cross section given by Cook in UCRL-10130 were used in the phase shift analysis. The six sets of solutions can be broken up into 3 groups of 2 sets each with the sets in each group approximately related by the Fermi-Yang ambiguity. One of these groups is very similar to the two Fermi-Yang solutions which workers at lower energies have favored. Only one of these two sets predicts a value for the $K^+ - n$ total charge exchange cross section which is close to the apparent plateau value found at lower energies. None of the other sets predicts a reasonable value for the $K^+ - n$ charge exchange cross section. (auth)

**2374** CHARACTERISTICS OF NUCLEAR INTERACTIONS PRODUCED BY 17 GeV NEGATIVE PIONS IN NUCLEAR EMULSIONS. Haque, M. B.; Khatun, H.; Haque, N.; Siddique, H. R.; Khatun, L.; Zaman, B. (Univ. of Dacca, Pakistan). J. Natur. Sci. Math., 6: 21-32(Apr. 1966).

Nuclear interactions produced by negative pions of energy 17 BeV in nuclear emulsions were analyzed to deduce useful information regarding some of the characteristics of pion-nucleon collisions. 500 disintegrations were observed while scanning 95.83 sq. cm. of the stack of Ilford G-5 nuclear emulsion plates of size 15 cm × 7.5 cm and exposed to a separated beam of 17 BeV negative pi mesons at CERN. Accurate measurements of multiple scattering and of grain density were made on favorable tracks of relativistic secondary particles. Mean free path of interaction of negative pions in emulsion is found equal to 40.25 ± 5.26 cms. The mean multiplicities of shower particles $\bar{n}_s$ and of heavy prongs, $\bar{N}_h$, are equal to 3.57 ± 0.22 and 8.1 ± 0.25 respectively. Mean number of shower particles, $\bar{n}_s$, per interaction for light stars ($N_h < 7$) and heavy stars ($N_h \geq 7$) are 2.49 ± 0.15 and 4.47 ± 0.28

respectively. The laboratory angular distributions of shower particles were investigated and the median angle for all events is found equal to 10.4 ± 1.07°. (auth)

**2375** $\pi^-p \rightarrow \pi^0 n$ POLARIZATION AT 5.9 AND 11.2 GeV/c. Bonamy, P. (CEN, Saclay, France); Borgeaud, P.; Bruneton, C.; (and others). Phys. Lett., 23: 501-5(Nov. 21, 1966).

The polarization parameter $P_0(t)$ in $\pi^-p$ charge exchange scattering was measured at 5.9 BeV/c and at 11.2 BeV/c in the range of four-momentum transfer $0.02 \leq -t \leq 0.3$ (BeV/c)$^2$. (auth)

**2376** MEASUREMENT OF $K^- + p \rightarrow K^* + N$; CALCULATION OF $K^* - N$ CROSS SECTION. Dickenson, M.; Miyashita, S.; Huwe, D.; Ayer, F.; Marshall, L. (Univ. of Colorado, Boulder). Phys. Lett., 23: 505-8(Nov. 21, 1966).

The total and differential production cross sections of $K^{*-}$ and $K^{*0}$ were evaluated for 2.0 and 2.24 BeV/c beam momentum $K^-p$ collisions. With an application of the optical model, the elastic scattering cross section and total cross section for the systems $K^{*-}p$ and $K^{*0}n$ were computed. (auth)

**2377** LOW-ENERGY $K^-p$ CHARGE-EXCHANGE INTERACTION. Kittel, W.; Otter, G.; Wacek, I. Acta Phys. Austr., 23: 343-5(1966). (In German).

The charge exchange channel $K^- + p \rightarrow \bar{K}^0 + n$ was investigated in the Saclay H cloud chamber in the pulse region from 89 to 300 MeV/c. The effective cross sections were calculated. Calculations showed that the capture of the stopping $K^-$ occurs by S wave interactions with a probability of 96%. There is an 89% probability of S and P wave interactions. The scattering length was calculated by two methods. The results indicated that the spin of the 1405 $Y_0^*$ is ½ with a parity of −1. (J.S.R.)

**2378** OBSERVATION OF MUON PAIRS PRODUCED BY HIGH-ENERGY NEGATIVE $\tau$ MESONS. Wehmann, A. (Harvard Univ., Cambridge, Mass.); Engels, E. Jr.; Hand, L. N.; Hoffman, C. M.; Innocenti, P. G.; Wilson, Richard; Blanpied, W. A.; Drickey, D. J.; Stairs, D. G. Phys. Rev. Lett., 17: 1113-16(Nov. 21, 1966).

From an experiment to measure the production of meson ($\mu$) pairs by 12-GeV/c mesons ($\pi^-$) conclusive evidence for a broad resonance at 760 MeV in the meson ($\mu$) pair effective mass distribution is reported. This resonance is attributed to the coupling of mesons ($\rho$) to meson ($\mu$) pairs via virtual intermediate photons. Also the data strongly favor the one-pion-exchange production mechanism for the meson ($\rho^0$). No evidence was found for an additional meson ($\rho^1$) which is heavier than the meson ($\rho$). (J.F.P.)

**2379** LOW-MASS $K\bar{K}$ SYSTEMS PRODUCED IN $\pi^-p$ INTERACTIONS BELOW 5 BeV/c. Hess, Richard I.; Dahl, Orin I.; Hardy, Lyndon M.; Kirz, Janos; Miller, Donald H. (Univ. of California, Berkeley). Phys. Rev. Lett., 17: 1109-12(Nov. 21, 1966).

In a study of $K\bar{K}$ pairs produced in $\pi^-p$ interactions from 1.5 to 4.2 BeV/c, the $K_1^0K_1^0$ threshold enhancement at all beam momenta, and the $\varphi$ meson at beam momenta below 2.3 BeV/c are observed. There are no significant enhancements in the $K^0K^-$ system near threshold. (auth)

**2380** CORRELATION OF $\pi\pi$-SCATTERING ANGLE AND DIPION MASS IN THE VICINITY OF THE $\rho$ MESON. Jabiol, M. A. (Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France); James, F. E.; Nguyen, Huu Khanh. Phys. Rev. Lett., 17: 1065-7 (Nov. 14, 1966).

One observed deviation from the expectations of the one-pion-exchange model in $\rho$-meson production was presented as evidence for a new T = 0, J = 0 resonance. It is shown that a similar effect is seen in a state which cannot have T = 0 and, therefore, must have another explanation. (auth)

**2381** INVESTIGATION OF THE EXCHANGE SCATTERING $\pi^- + p \rightarrow \pi^0 + n$ AT 2.8 GeV/c. Barmin, V. V.; Dolgolenko, A. G.; Meshkovskii, A. G.; Shebanov, V. A. Yadern. Fiz., 4: 833-8(Oct. 1966). (In Russian).

The reaction $\pi^- + p \rightarrow \pi^0 + n$ was investigated for the $\pi^-$-meson momentum 2.8 GeV/c. The total cross section of this reaction is $\sigma = 0.35 \pm 0.04$ mb. Along with the maximum near 0°, a second maximum was observed in the angular distribution $d\sigma/d\Omega$ in the region $0.3 < \cos\theta < 0.45$, corresponding to the squared momentum transfer $t \cong -1.4$(GeV/c)$^2$. The values of $d\sigma/d\Omega$ at 0 and 180° are equal to 220 ± 30 and 5 ± 5 $\mu$b/sterad respectively. (auth)

**2382** EMISSION OF HIGH-ENERGY NEUTRONS FROM $\pi^-$–Xe INTERACTIONS AT 9 GeV. Anghelescu, D.; Datcu, V.; Friedlaender, E. M.; Nitu, R.; Preda, A. Bul. Inst. Politeh. Bucuresti, 28: No. 2, 35-8(Mar.-Apr. 1966).

For inelastic interactions $\pi^-$–Xe at 9 GeV with $\overline{\Delta^2} = (3.3 \pm 1.1)$ (GeV/c)$^2$ the value (0.76 ± 0.27) mb/nucleon was obtained as a lower limit of the cross section. (auth)

**2383** $K^+p$ PHASE SHIFT ANALYSIS. Lea, A. T. (Niels Bohr Inst., Copenhagen); Martin, B. R.; Oades, G. C. Phys. Lett., 23: 380-2(Nov. 7, 1966).

In a preliminary phase shift analysis of $K^+p$ data possible evidence for a strangeness +1 baryon resonance was found. (auth)

**2384** ON THE POSSIBLE N* PRODUCTION OF MASS ABOUT 1.47 GEV/C$^2$ IN THE $K^-p \rightarrow K^-p\pi^0$ CHANNEL AT 1.45 GEV/C. Fridman, A. (Univ., Heidelberg); Maurer, G.; Michalon, A.; Schiby, B.; Strub, R.; Zech, C.; Cueer, P. Phys. Lett., 23: 386-9 (Nov. 7, 1966).

The channel $K^-p \rightarrow K^-p\pi^0$ at 1.45 GeV/c was investigated in order to see the production of a possible N*(1470) isobar. Within the statistics the observed enhancement in the $p\pi^0$ mass is compatible with the existence of a N*(1470). (auth)

**2385** INTERFERENCE EFFECTS IN THE REACTION $K^+ + p \rightarrow K + N + \pi$ AT 1.2 BEV/C. Bland, Roger W.; Bowler, Michael G.; Brown, John L.; Goldhaber, Gerson; Goldhaber, Sulamith; Kadyk, John A.; Trilling, George H. (Univ. of California, Berkeley). Phys. Rev. Lett., 17: 939-42(Oct. 24, 1966). (UCRL-16967)

Substantial interference was observed between N* and K* production in 1.2-BeV/c $K^+$-p interactions. (auth)

**2386** $K^-p$ CHARGE EXCHANGE AT 5, 7 AND 12 GEV/C. Astbury, P. (CERN, Geneva); Brautti, G.; Finocchiaro, G.; (and others). Phys. Lett., 23: 396-400(Nov. 7, 1966).

The results obtained from a magnet spark chamber experiment on $K^-$-p charge exchange from 5 to 12 GeV/c are presented. Also the results are compared with the prediction of a Regge pole model. (auth)

**2387** MULTIPLE PION PRODUCTION IN $\pi^-p$ REACTIONS AT 5.5 GEV/C. Cole, James Arthur. Baltimore, Johns Hopkins Univ., 1966. 216p.

Thesis.

The interaction of $\pi^-$ mesons with protons leading to final states with six charged particles were studied. The experiment was performed with the 80 in. hydrogen bubble chamber with an unseparated 5.5 GeV/c beam. The only strong resonance production observed was that of the $\Delta^{++}$ (1238) in the events with no neutrals and the $\omega^0$ in the events with one $\pi^0$. The production process for all events was found to be predominantly nonperipheral and consistent with P and T invariance. An attempt was made to calculate the cross sections for final states with from three to ten particles, using isospin invariance. There was a large decrease in the cross section for six particle as compared to five particle final states. This decrease could correspond to a change in the production mechanism from a predominantly peripheral to a predominantly nonperipheral interaction. (Dissertation Abstr.)

**2388** USE OF THE REACTION $\pi^+ + p \rightarrow \Sigma^+ + K^+$ TO DETECT THE $\Sigma^+$ HYPERON AND MEASURE ITS MAGNETIC MOMENT. Ewart, Terry Everett. Seattle, Univ. of Washington, 1965. 156p.

Thesis.

The design and use of apparatus to measure the magnetic moment of the $\Sigma^+$ hyperon using the reaction $\pi^+ + p \rightarrow + \Sigma^+ + K^+$ is discussed. Particular attention is paid to the detection of the $K^+$ meson. Detection of the $K^+$ from the above reaction was used to trigger a small spark chamber located in a high (150–200 kilogauss) magnetic field. The $\Sigma^+$ and its subsequent decay ($\Sigma^+ \rightarrow p + \pi^0$) were observed in the spark chamber, and the distribution of the decay protons for all of the events was obtained. The $\Sigma^+ \rightarrow p + \pi^0$ decay violates parity conservation and the decay proton distribution is asymmetric with respect to the $\Sigma^+$ spin axis. If the $\Sigma^+$ possesses a magnetic moment, its spin axis will precess in the magnetic field, and the asymmetric decay distribution of the $\Sigma^+$ can be used to observe this precession. Only 387 events have survived the selection criteria, and analysis of these events yields a $\Sigma^+$ magnetic moment of 1.50 ± 1.07 nuclear magnetons. The analysis of the data is discussed and the results are compared with current theoretical predictions. (Dissertation Abstr)

# Particle Interactions and Properties (Theoretical)

## General

*Refer also to abstract 2526.*

**2389** (NP-16365) PROCEEDINGS OF THE VAASA SUMMER SCHOOL IN THEORETICAL PHYSICS [HELD IN VAASA, FINLAND], JUNE 16–24, 1965. (Helsinki Univ. (Finland). Research Inst. for Theoretical Physics). Sept. 1965. 138p. Dep. mn.

The discussion of bootstraps and N/D techniques includes the

basis of S-matrix theory, N/D techniques for solving dynamical problems, Regge poles, and an example of the Regge–SU(3)–bootstrap calculation. Superhigh energy problems, a uniform rigorous treatment of stable and unstable particles in quantum field theory, a rigorous framework for relativistic quantum theory, interactions involving unstable particles, and a table of old and new data on particles and resonances are also presented. (J.F.P.)

**2390** (TID-23318, pp 1-5) NEUTRALITY OF THE NEUTRON. Billman, K. W.; Skull, C. G.; Wedgwood, F. A. (Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics).

An experiment was undertaken to examine more closely the limit that may be placed on a possible charge possessed by the free neutron. The implications of such a charge are numerous. The experimental technique employed was to subject a beam of neutrons to a strong, uniform, reversible, transverse electric field. The experimental arrangement is illustrated and experimental results are exhibited. A least-squares fit of the data gave $(-2.0 \pm 3.8)\ 10^{-18}$ e. (W.D.M.)

**2391** ELEMENTARY PARTICLES AND RESONANCES. Ijaz, Mujaddid A. (Virginia Polytechnic Inst., Blackburg). J. Natur. Sci. Math., 6: 67-76(Apr 1966).

A brief survey is given of the study of elementary particles and resonances. (L.B.S.)

**2392** HILBERT SPACE TECHNIQUES. Yahya, Q. A. M. M. (Univ. of Dacca, Pakistan). J. Natur. Sci. Math., 6: 17-19(Apr. 1966).

Problems in elementary particle physics and quantum mechanics demand separable Hilbert space. Starting from the statistical approach to the problem of fluctuation of pions in nucleon clouds, the techniques of operators defined on Hilbert space relating to this and relevant problems are discussed. (auth)

**2393** FIZIKA ELEMENTARNYKH CHASTITS. (Elementary Particle Physics). Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. 116p.

Separate abstracts were prepared for each of the thirteen papers included. (G.O.Y.)

*For abstracts of individual chapters see: 1408, 1590–1594, 2360, 2407, 2408, 2439, 2450, 2629, and 2630.*

**2394** TIME DEPENDENCE OF UNSTABLE-PARTICLE DECAY. Frazer, W. R.; Peyton, S. (Univ. of California, San Diego, La Jolla). Ann. Phys. (N. Y.), 40: 46-53(Oct. 17, 1966).

The exponential decay law of unstable particles is discussed in the framework of a multichannel scattering problem. Particular attention is given to the power-law terms. They are shown to be very general phenomena, associated with all thresholds and occurring whether or not there are unstable particles produced. A simple physical interpretation is proposed. (auth)

**2395** APPLICATION OF THE MICROCANONICAL DISTRIBUTION TO THE STATISTICAL THEORY OF MULTIPLE PRODUCTION OF PARTICLES. Hayashi, M. (Univ. of Friendship of Nations, Moscow). Bull. Acad. Pol. Sci., Ser. Sci. Math. Astron. Phys., 14: 395-400(1966).

The statistical weight of production of N particles of one sort is calculated in the nonrelativistic and ultrarelativistic cases. The first correction of the quantum statistics to the Boltzmann statistical weight is similarly calculated. It is concluded that the effect of taking into consideration the quantum statistics is appreciable in the case of the nonrelativistic approximation, but, in the case of the ultrarelativistic approximation, it is not very effective and therefore can be neglected. (L.B.S.)

**2396** GENERAL NONDYNAMICAL FORMALISM FOR REACTIONS WITH PARTICLES OF ARBITRARY SPIN: ROTATION INVARIANCE. Csonka, Paul L.; Moravcsik, Michael J.; Scadron, Michael D. (Univ. of California, Livermore). Ann. Phys. (N. Y.), 40: 100-26(Oct. 17, 1966).

A detailed and practical prescription for calculating physical observables from form factors (i.e., invariant amplitudes) of the M-matrix for an arbitrary reaction containing an arbitrary number of particles having arbitrary spins is given. The treatment is fully relativistic. No invariance principles are assumed (except rotational invariance in three space) and the discussion is valid whether or not any of the usual invariance principles (parity conservation, time-reversal invariance, etc.) hold. The factorizability of the M-matrix in spin-space, the treatment of nonsquare spin matrix tensors, and the general evaluation of traces of products of spin tensors are treated. The expansion of the M-matrix in terms of spin-momentum tensors is explained for the general case, and a similar discussion is given for the density matrix. From these the observables are calculated, and the mathematical background of such calculations is treated. (auth)

**2397** COMPLEX ANGULAR MOMENTUM STATES IN QUANTUM MECHANICS. Sannikov, S. S. Yadern. Fiz. 4: 896-904(Oct. 1966). (In Russian).

The complex angular momentum method is applied to an investigation of unstable states in quantum mechanics. A particular class of solutions of the Schroedinger equation is considered, corresponding to the free motion of unstable particles, bound unstable states and decaying states of nuclei. Poles of the scattering matrix $S_l(E)$ in the region $\mathrm{Re}\ E < 0$, correspond to bound unstable states. Representations of the rotation group, corresponding to complex momenta, are used to describe all such states. (auth)

**2398** SPIN TESTS FOR BOSONS DECAYING INTO THREE SPINLESS PARTICLES. Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 884-6(Oct. 1966). (In Russian).

A possible method is suggested to determine the spin of bosons produced in reactions of the type $0 + 0 \rightarrow 0 + S$ and decaying into three spinless particles. It is shown that the coefficient for the highest Legendre polynomial in the angular correlation between the normals to the production and decay planes cannot vanish and that its absolute value is restricted from below. The angular correlation is predicted uniquely in a number of important cases. (auth)

**2399** EQUATION FOR THE FOUR-PARTICLE AMPLITUDE IN TERMS OF THE TWO-PARTICLE ONE. Beloozerov, N. N. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz., 4: 887-91(Oct. 1966). (In Russian).

The Schroedinger equation is transformed so as to exclude the potential. Equations analogous to the Fadeev three-particle equations are obtained. (auth)

**2400** COMPACT AND FORMAL EXPRESSION FOR ASYMPTOTIC OPERATORS. Sirugue-Collin, M.; Sirugue, M. (Faculte des Sciences, Marseille, France). Nuovo Cimento (10), 465A: 588-606(Oct. 1, 1966).

A formal and compact form for asymptotic creation and annihilation operators is derived. Connection to the well-known theory of formal scattering is given. The obtained formulas enable a study of commutation relations for elementary-particle asymptotic operators; some results pertinent in the cases where bound states are present are also given. (auth)

**2401** A CURRENT ALGEBRA RELATION BETWEEN PCAC AND VECTOR MESON DOMINANCE. Renner, B. (Univ. of Cambridge, Eng.). Nuovo Cimento (10), 45A: 689-95(Oct. 1, 1966).

Cases are found where current algebra commutators require approximate validity of PCAC both for the strangeness-conserving and strangeness-changing axial vector current, if the usual assumptions of unsubtracted dispersion relations for matrix elements of the vector currents are to be maintained. (auth)

**2402** MINIMAL INTERACTIONS AND SOFT-PION EMISSION PROCESSES. Pasupathy, J. (Univ. of Rochester, N. Y.). Nuovo Cimento (10), 45A: 780-4(Oct. 1, 1966). (UR-875-162).

It is pointed out that many of the equations for soft-pion emission processes can be derived on a general basis using simple applications of the current algebra. (L.B.S.)

**2403** ANGULAR DISTRIBUTION DEPENDENCE ON TRANSVERSE MOMENTUM IN HIGH ENERGY COLLISIONS. Yabuki, Haruichi (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 36: 415-16(Aug. 1966).

The possibility that the angular distribution dependence on the transverse momentum in high-energy collisions is a necessary consequence of the Lorentz contraction of the interacting region is investigated. (L.B.S.)

## *Electromagnetic*

**2404** (SLAC-PUB-225) ELECTRODYNAMIC INTERACTIONS. Drell, S. D. (Stanford Linear Accelerator Center, Calif.). Sept. 1966. Contract AT(04-3)-400. 57p. (CONF-660808-20). Dep. mn. CFSTI $3.00 cy, $0.50 mn.

From 13th International Conference on High Energy Physics, Berkeley, Calif.

Major experimental progress is reported in three areas. They are: the electromagnetic form factors of the proton at large space-like and time-like values of the square of the invariant momentum transfer $q^2$; the photoproduction of electron-positron and muon pairs as high momentum tests of quantum electrodynamics; and the muon g-2 value. The implications for understanding of the hadron form factors and for increasing or delineating the domain of validity of Q.E.D. is considered. (auth)

**2405** BREMSSTRAHLUNG DURING SCATTERING OF ULTRARELATIVISTIC ELECTRONS. Guzenko, S. Ya.; Kolesnikov, V. M.

(Inst. of Physics and Tech., Kharkov). Ukr. Fiz. Zh., 11: 915-17 (1966). (In Ukrainian).

A functional integration method was used for determining matrix elements of various processes without applying the theory of perturbation. The method proved satisfactory for the case of relativistic electron interactions in which the slow electromagnetic fields are main contributors to the matrix element. In such a case the resolution for Dirac equation was obtained by the Wentzel-Kramers-Brillouin method. (R.V.J.)

**2406** RADIATIVE CORRECTIONS FOR INELASTIC ELECTRON SCATTERING. Bartl, A. (Univ., Graz). Acta Phys. Austr., 23: 127-30(1966). (In German).

The radiative corrections for inelastic electron scattering $e + p \rightarrow e + n + \pi^+$ were derived for the experimental installation used at Cornell University for the study of this process. The formulas derived are valid, not only for this experiment, but for an additional class of experiments. (J.S.R.)

**2407** MUON BREMSSTRAHLUNG ON ELECTRONS. Erlykin, A. D.; Mikhailov, V. D. pp 83-6 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The bremsstrahlung effect of relativistic muons interacting with atomic electrons is investigated theoretically. Because of their relativistic energy, the atomic electrons are considered as free particles. The total cross section for this interaction is calculated. It consists of two parts: the equivalent-photon scattering cross section for electrons on muons and the equivalent-photon scattering cross section for muons on electrons. (G.O.Y.)

**2408** ON THE CROSS SECTION OF MUON BREMSSTRAHLUNG AT HIGH ENERGIES. Petrukhin, A. A.; Shestakov, V. V. pp 102-6 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

It is shown that the cross section of muon bremsstrahlung, taking into account electron screening of the nucleus, is in agreement with the method proposed by Bethe and Gaitler for the derivation of an analogous expression. (G.O.Y.)

**2409** VECTOR MESON EMISSION BY LEPTONS IN NUCLEAR COULOMB FIELDS. Andersen, C. M. (Purdue Univ., Lafayette, Ind.); Halprin, A.; Primakoff, H. Ann. Phys. (N. Y.), 40: 54-99(Oct. 17, 1966).

It is proposed that experiments be undertaken which study the emission of $\varphi$, $\omega$, and $\rho^0$ by very high energy electrons or muons incident on the Coulomb fields of high-Z nuclei. A determination of the cross section for this process would provide an indirect way of measuring decay rates of the type $V \rightarrow l^+ + l^-$ where $V = \varphi, \omega$, and $\rho^0$ and $l^+ = e^+, \mu^+$. The cross section for the reaction $l^+ + Z \rightarrow l^+ + V + Z$, where V is emitted from a lepton-lepton-meson vertex, is derived and some estimates are made of background processes. (auth)

**2410** ON THE MOTION OF A NEUTRAL DIRAC PARTICLE WITH AN ANOMALOUS MAGNETIC MOMENT IN AN ELECTRIC FIELD. Ternov, I. M.; Bagrov, V. G. (Moscow State Univ.). Yadern. Fiz., 4: 797-800(Oct. 1966). (In Russian).

The motion of a neutral fermion with an anomalous magnetic moment in a one-dimensional electric field, constant in time, is considered. (auth)

**2411** FORBIDDEN CONFIGURATIONS IN THREE PHOTON SYSTEMS. Kopylov, G. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 801-6(Oct. 1966). (In Russian).

The effective matrix elements for the three-photon decays of spin-0 and -1 particles are listed. It is proved in general that collinear configurations and configurations with monoenergetic photons are forbidden for spin-0, contrary to spin-1 and -2. Characteristic distributions over the photon energies are given. (auth)

**2412** ELECTRON AND PHOTON EQUILIBRIUM SPECTRA WITH MEDIUM POLARIZATION AND MULTIPLE SCATTERING TAKEN INTO ACCOUNT. Ivanenko, I. P.; Samosudov, B. E. (Moscow State Univ.). Yadern. Fiz., 4: 807-11(Oct. 1966). (In Russian).

Expressions are obtained for electron and photon equilibrium spectra in the B approximation of the cascade theory, taking the medium polarization into account. Expressions are obtained for the equilibrium spectra, taking scattering into account showers, produced by a particle with given finite energy $E_0$. (auth)

**2413** ARE QUARKS FRACTIONALLY OR INTEGRALLY CHARGED? Khanna, M. P.; Okubo, S. (International Centre for Theoretical Physics, Trieste, Italy). Ann. Phys. (N. Y.), 40: 153-8(Oct. 17, 1966).

On the basis of algebra of currents, the decay rate $\pi_0 \rightarrow 2\gamma$ and the axial vector renormalization constant $g_A$ are computed. These numbers are model dependent, and it is found that the fractionally charged quark model gives more satisfactory results than the integrally charged quark model. (auth)

**2414** POLARIZATION EFFECTS IN THE REACTION $\gamma + p \rightarrow p + \eta^0$. Lazarenko, L. A. Yadern. Fiz., 4: 881-3(Oct. 1966). (In Russian).

A method of investigating the role of the D-wave at the threshold of the $\eta^0$-meson photoproduction on a nucleon is considered. The possible existence of a $S_{11}$-resonance is demonstrated. (auth)

**2415** THE BERNSTEIN, FEYNBERG, AND LEE HYPOTHESIS AND HYPERCHARGED PARTICLES. Zakharov, V. I.; Kaidalov, A. B. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz., 4: 862-7(Oct. 1966). (In Russian).

It is suggested that the C-parity-violating electromagnetic interaction of hadrons, suggested by Bernstein, Feynberg and Lee, changes the hypercharge. Various models of CP violation are obtained in dependence on the hypercharge selection rules in the moderately strong, ordinary electromagnetic and weak interactions. The experimental consequences of these models are considered. (auth)

**2416** ELECTROMAGNETIC TRANSITION FORM FACTORS AND INELASTIC ELECTRON-HADRON SCATTERING. Kondratyuk, L. A. Yadern. Fiz., 4: 825-32(Oct. 1966). (In Russian).

The cross section and the density matrix for the inelastic scattering of electrons on hadrons with arbitrary spin are determined in the single photon exchange approximation in terms of the electromagnetic form factors introduced by Durand et al. The T-noninvariant effects and the angular distribution of the final hadrons in the process $e + N \rightarrow e' + N^* \rightarrow e' + N + \pi$ are discussed. (auth)

**2417** FOUR-FERMION INTERACTIONS AND THE ELECTROMAGNETIC MASS DIFFERENCES OF BARYONS. Ivanter, I. G. Yadern. Fiz., 4: 839-42(Oct. 1966). (In Russian).

The possible physical meaning of a four-fermion interaction model, developed previously, is discussed. The relative magnitudes of the electromagnetic mass differences of decuplet baryons are calculated with the help of this model, using data on the electromagnetic mass splitting for octet baryons. In particular, it is predicted that $(\Delta^- - \Delta^{2+})/(Y^- - Y^+)$ should be ~1, in contrast to the minimal octet variant of SU(3), in which as is well known, this ratio should be equal to $\frac{3}{2}$. (auth)

**2418** PION ELECTROPRODUCTION AND AXIAL CURRENT. Vainshtein, A. I.; Sokolov, V. V.; Khriplovich, I. B. (Novosibirsk State Univ., USSR). JETP Lett. (USSR) (Engl. Transl.), 4: 132-4(Sept. 1, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redakt., 4: 193-6(Sept. 1, 1966).

Using the algebra of single-time commutators, a generalization of the Kroll–Ruderman theorem which includes the case of electroproduction of mesons ($\pi$) at momentum transfers of about $\mu^2$ is derived. (J.F.P.)

**2419** SIGN OF THE PROTON-NEUTRON MASS DIFFERENCE AND A GHOST SCALAR MESON. Suzuki, Mahiko; Zachariasen, Fredrik (California Inst. of Tech., Pasadena). Phys. Rev. Lett., 17: 1033-5(Nov. 7, 1966).

It is shown that the model given previously by Pagels and Fried and Truong for interpreting the proton-neutron mass difference implies a ghost scalar meson with T = 1 and G = −1. Spontaneous symmetry breaking theory is used. By identifying the ghost with that of the Regge-pole model, the magnitude of the feedback can be roughly estimated by means of a linear extrapolation. (J.F.P.)

**2420** ELECTRON (OR MUON) PRODUCTION OF N* AND FORM FACTORS OF THE $\gamma$ NN* VERTEX. Kessler, Paul (College de France, Paris). Ann. Inst. Henri Poincare, Sect. A, 3: 363-85(Oct. 1–Dec. 31, 1965). (In French).

The differential cross section of the reaction $e + N \rightarrow (e + N^*_{33}) \rightarrow e + N + \pi$ was calculated with respect to four independent final state parameters. This calculation was done in an extremely simplified (and yet rigorous) way through a triple factorization procedure. The final expression appears as a very simple function of the three helicity amplitudes which exist for the process $\gamma + N \rightarrow N^*$, and which are themselves linear functions of the three form factors of the $\gamma$NN* vertex. The extension of the method to electroproduction of higher baryonic resonances is discussed, and calculations were done also for those resonances. Finally, the importance of future experiments of electroproduction of the suggested type, with coincidence detection of both outgoing charged particles is stressed. (auth)

**2421** ON THE ISOBAR MODEL FOR PION PHOTOPRODUCTION. Raszillier, I. (Inst. of Physics, Bucharest). Phys. Lett., 23: 378-80(Nov. 7, 1966).

It is shown that in an adequate formulation of the isobar model wrong multipoles from direct diagrams do not appear. The expressions of the multipole amplitudes from baryon resonances of arbitrary spin are given and "absorptive" corrections are discussed. (auth)

**2422** STUDY OF A CONSISTENT THEORY FOR SPIN-2 MESONS. Minkowski, P. (Eidgenoessische Technische Hochschule, Zurich). Helv. Phys. Acta, 39: 477-506(1966). (In German).

The electromagnetic interaction of a charged spin-2 meson is considered. Several canonical transformations of both the meson and photon field lead to an interaction representation. The hamiltonian expressed by the interaction picture fields is a noncovariant power series in the charge. On the other hand the time-ordered products of the fields and their derivatives contain noncovariant terms of a $\delta^{(4)}(x)$ type, which give rise to higher order vertices compensating the noncovariant contributions from the hamiltonian. The latter is calculated in second order approximation and reduced to a simple form making use of covariant contractions. The multipole moments in nonrelativistic limit are obtained. The "minimal coupling" admits a free parameter $\alpha$ which corresponds to an anomalous magnetic moment (e: charge, M: meson mass, $\vec{S}$: meson spin). $\vec{\mu} = -(\alpha/2)\,(e/2M)\,\vec{S}$. (auth)

**2423** ELECTROMAGNETIC DECAY AND ELECTRIC PRODUCTION OF THE $3/2^+$ RESONANCE. Belyaev, V. B.; Dao Wong Duc; Nguyen Van Hieu (Joint Inst. for Nuclear Research, Dubna, USSR). Dokl. Akad. Nauk SSSR, 167: 312-15(Mar. 11, 1966). (In Russian).

A general expression is given for the probability of an electromagnetic decay and the cross section for the electroproduction of a resonance in order to compare experimental data with theoretical predictions on the basis of U(12) symmetry. The expression is simplified considerably by assuming U(12) symmetry. An expression is derived for the electromagnetic decay: $B^* \rightarrow B + \gamma$. The following estimates were obtained for various decay probabilities: $\Gamma(N^{*+} \rightarrow p + \gamma) = 0.177$ MeV, $\Gamma(Y^{*0} \rightarrow \Lambda + \gamma) = 0.141$ MeV, $\Gamma(Y^{*+} \rightarrow \Sigma^+ + \gamma) = 0.083$ MeV, and $\Gamma(\Xi^{*0} \rightarrow \Xi^0 + \gamma) = 0.179$ MeV. The electrogeneration of a $3/2^+$ baryon on a $1/2^+$ baryon is also considered: $e^- + B \rightarrow B^* + e^-$. The expression for the differential cross section is considerably simplified in the case of U(12) symmetry. The experimental data on the electroproduction of $\pi$-mesons do not contradict the theoretical predictions. (TTT)

**2424** INVESTIGATION OF ELECTROMAGNETIC FORM FACTORS FOR ELEMENTARY PARTICLES. Kessler, Paul; Bhattacharya, Asit (College de France, Paris). Bol. Univ. Parana, Fis. Teorica, No. 8, 1-20 (Dec. 1965). (In French).

The status of research on electromagnetic form factors of elementary particles is discussed. Beginning with Hofstadter's experiments and deductions about nuclear and nucleon structure, the experimental and theoretical results for the form factors of various elementary particles are considered. Special attention is given to the electroproduction of pions and the production of heavy photons. (G.O.Y.)

**2425** ON THE RADIATIVE CORRECTIONS IN WIDE-ANGLE ELECTRON PAIR PRODUCTION. Ferrari, E.; Thurnauer, P. G. (Univ. of Rochester, N. Y.). Nuovo Cimento (10), 45A: 752-6 (Oct. 1, 1966).

A detailed study is made of a particular configuration which is relevant to recent experiments on wide-angle electron pair production on carbon, namely, the creation of a symmetric electron-positron pair with the emission of an additional forward photon. Calculations are made of the contribution to the radiative cross section for the symmetric case. Results are also presented for one of the configurations given by De Tollis, Jona-Lasinio and Liotta, where the four-momenta of the electron and positron are equal. (L.B.S.)

**2426** THE n-p MASS DIFFERENCE AND THE MASS SPLITTINGS OF N* (1238 MeV). Kinoshita, K. (Tokyo Univ.). Nuovo Cimento (10), 45A: 725-29(Oct. 1, 1966).

An attempt is made to explain the n-p mass difference by examining the contribution of the $\pi N^*$ together with $\pi N$ and $\gamma N$, assuming that the dispersion integral for the self-energy is unsubtracted and that the breakdown of the charge independence is mainly caused by the mass splittings of particles in intermediate states. (L.B.S.)

**2427** CURRENT ALGEBRA AND THE DECAY $\eta \rightarrow 3\pi$. Sutherland, D. G. (CERN, Geneva). Phys. Lett., 23: 384-5 (Nov. 7, 1966).

The process $\eta \rightarrow 3\pi$ is discussed by current algebra techniques and is found to be forbidden. Possible explanations of this alarming result are discussed briefly. (auth)

**2428** SUM RULE FOR THE MAGNETIC MOMENT OF THE DIRAC PARTICLE. Hosoda, Masataka; Yamamoto, Kunio (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 36: 425-6(Aug. 1966).

An exact sum rule is presented for the magnetic moment of the proton, which relates only experimentally measurable quantities. The sum rule is expected to hold for any kind of Dirac particle. (L.B.S.)

**2429** HAMILTONIAN TREATMENT OF THE INTERACTION OF CHARGED PARTICLES BY ACTION-AT-A-DISTANCE. Daughaday, Hamilton Jr. Buffalo, State Univ. of New York, 1965. 113p.

Thesis.

The Hamiltonian treatment of the electrodynamic interaction of charged particles by action-at-a-distance was studied for both the classical and quantum mechanical cases. A method is developed for extending Kerner's treatment of the nonrelativistic classical case to particles moving with relativistic kinetic energies. The classical Hamiltonian takes the form of a series in powers of $(e^2/mc^2)/r$, the ratio of the charge radius to the separation distance between charges. A partial differential equation in the momentum variables is obtained for each term in the series, and a general method is developed for solving these equations. A quantum mechanical Hamiltonian for charged spinless particles is obtained by quantizing the classical Hamiltonian and symmetrizing the results. A unique procedure is derived for carrying out the quantization and symmetrization based on methods given by Weyl and McCoy. Two independent deductions are made of the character of the Hamiltonian for charged particles of spin $1/2$. In the first approach, spin is introduced phenomenologically in quantizing the classical Hamiltonian. In the second approach, an action-at-a-distance modification of Møller's scattering matrix element was obtained by replacing retarded interactions by $1/2$ retarded plus $1/2$ advanced interactions. The terms of order $e^2$ and $1/c^4$ in the Hamiltonian were deduced from a study of this modified matrix element. (Dissertation Abstr)

**2430** DIFFUSION DES ELECTRONS DE HAUTE ENERGIE. (Scattering of Electrons at High Energies). Gourdin, M. Collection de Monographies de Physique. Paris, Masson et Cie Editeurs, 1966. 234p. 54 F.

A theoretical analysis of experimental results which uses to the maximum the principles of invariance and thus gives all information independently of a theory of strong interactions is given. The study is limited to a detailed consideration of elastic and inelastic electron-proton and electron-deuteron scatterings. The problems of electron-nucleus and those of radiative corrections are not dealt with. (J.S.R.)

**2431** ELECTROPRODUCTION OF THE $7/2^+$ RESONANCE, AND LEPTON PAIR PRODUCTION FROM THIS RESONANCE. Kessler, P. (College de France, Paris). 5p. (CONF-650977–2). ORAU.

From Conference on Nuclear and Particle Physics, Liverpool, England.

The $l + p \rightarrow l + N + \pi$ and $\pi^- + p \rightarrow l^- + l^+ + n$ interactions are considered in order to determine the electromagnetic form factor for $\gamma NN^*$ vertices for space-like and time-like photons, respectively. Calculations are made for both processes in isobaric models by considering the mass of the pion-nucleon system to be that of any of the first four baryonic resonances $N^*$ ($3/2^+$, $3/2^-$, $5/2^+$, $7/2^+$), using a triple factorization procedure. The result is given for the $7/2^+$ resonance. (L.B.S.)

## Weak

*Refer also to abstract 2415.*

**2432** (AD-635060) REMARKS ON THE EQUAL-TIME COMMUTATOR OF AXIAL-VECTOR CURRENT COMPONENTS. Dietz, Klaus (Illinois Univ., Urbana. Dept. of Physics). 1966. Contract Nonr-1834(05). 16p. CFSTI $1.00 cy, $0.50 mn.

The matrix element of the equal-time commutator of the axial-vector current and its fourth component between one-nucleon states of the same momentum is investigated on the basis of very general principles. The dependence on the pion 4-momentum of Adler-Weisberger type relations for the renormalization of the axial-vector coupling constant is examined. Furthermore, the connection of Schwinger terms antisymmetric in the isospin indices with subtractions in the involved scattering amplitudes is shown. (auth)

**2433** (JINR-P-2823) RASPADY BARIONOV S OBRAZOVANIEM PARY DALITSA. (Baryon Decays With Dalitz Pair Formation). Veluev, B. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 11p. Dep. mn.

The process $B_1 \rightarrow B_2 + e^- + e^+$ is considered, where $B_1$ and $B_2$

are ½ spin baryons (or antibaryons). In the polar (singlephoton) approximation the measured values are expressed by four form factors, necessary to describe this process. The obtained expressions turn out to be helpful for the detailed checking CP invariance. General formulas, in which the electron mass is not neglected, are applied also to the decays with $\mu$ meson pair production. (auth)

**2434** S-OPERATOR THEORY OF WEAK INTERACTIONS. Pietschmann, Herbert; Nilsson, Jan (Univ. of Virginia, Charlottesville). Acta Phys. Austr., 23: 232-3(1966). (In German).

The theory of weak interactions is constructed in pure S-operator theory in order to obtain more valid results at higher approximations. (J.S.R.)

**2435** CALCULATION OF AXIAL FORM FACTORS OF SEMILEPTONIC BARYON DECAY. Majerotto, Walter (Univ., Innsbruck). Acta Phys. Austr., 23: 346-9(1966). (In German).

Expressions are derived for the axial form factors of semileptonic baryon decay. The expressions derived are directly comparable with experimental data. A numerical evaluation of $|G_A| = |G_1(0)| = 1.19\ |G_0|$, in good agreement with the experimental value of $|G_A/G_0| = 1.18 \pm 0.02$. (J.S.R.)

**2436** $K_1^0-K_2^0$ MASS DIFFERENCE AND POSSIBILITY OF A S-WAVE DI-PION RESONANCE ABOVE 500 MeV. Truong, Tran N. (Brown Univ., Providence). Phys. Rev. Lett., 17: 1102-5(Nov. 21, 1966). (NYO-2262TA-134).

Under the assumption that the sign and magnitude of $K_1^0-K_2^0$ mass difference is due to the contribution of the two-pion intermediate state in the self-energy dispersion integral, it is found that the I = 0 S-wave pion-pion interaction is strong near the K mass. The possibility of a di-pion resonance above 500 MeV is suggested. (auth)

**2437** K-MESON NONLEPTONIC DECAYS. Weyers, J. (Stanford Linear Accelerator Center, Calif.); Foldy, L. L.; Speiser, D. R. Phys. Rev. Lett., 17: 1062-5(Nov. 14, 1966).

The predictions of a current × current Hamilitonian in the nonleptonic decays of mesons(K) are re-examined. Previous results are improved by reducing only one or two mesons ($\pi$) in the decay $K \to 3\pi$. It is found possible to express all meson(K) decay amplitudes as functions of only one reduced matrix element. This leads to the predictions for ratios of decay amplitudes which are summarized. It is concluded that the current × current Hamiltonian agrees with all experimental results and it is thus favored over a pure octet Hamiltonian. (J.F.P.)

**2438** TEST OF TIME-REVERSAL INVARIANCE IN $K\mu\nu\gamma$ DECAY. MacDowell, S. W. (Yale Univ., New Haven). Phys. Rev. Lett., 17: 1116-18(Nov. 21, 1966).

A possible test of C nonconservation in the decay $K^+ \to \mu^+ + \nu + \gamma$ is discussed. An estimate is obtained for the transverse polarization in this decay under the assumption of strong C invariance violation in electromagnetic interactions. Although the polarization was found to be larger than that in $K_{\mu 3}$ it is too small to make the test experimentally favorable. (J.F.P.)

**2439** SIMULATION $K_2^0 \to 3\pi^0$ AND $K_2^0 \to \pi^+\pi^-\pi^0$ IN A BUBBLE CHAMBER BY MEANS OF THE MONTE-CARLO METHOD. Aleksanyan, A. M. S.; Gal'per, A. M.; Katenko, L. P.; Kuzin, L. A.; Merzon, G. I. pp 107-13 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

Detection of the $K_2^0 \to 3\pi^0$ decay depends on the exact determination of the number of events culminating in the production of 3, 4, 5, and 6 electron-positron pairs; detection of the $K_2^0 \to \pi^+\pi^-\pi^0$ decay depends on the number of one and two electron-positron pairs produced at the apex of a V-event. Taking into consideration the fact that not all the gamma quanta may have time to interact within the working region of the bubble chamber, and taking account also of the necessary conversion factor, a program was developed using the Monte Carlo method to calculate the $n_\alpha$ events (with alpha being the number of electron-positron pairs = 3,4,5,6) and the $n_\beta$ V-events (where beta is the number of electron-positron pairs = 1,2). These two calculations gave an accurate simulation of the $K_2^0 \to 3\pi^0$ and $K_2^0 \to \pi^+\pi^-\pi^0$ decays. (G.O.Y.)

**2440** POLARIZATION EFFECTS IN THE LEPTONIC DECAYS OF HYPERONS. Lyul'ka, V. A. Yadern. Fiz., 4: 793-6(Oct. 1966). (In Russian).

Polarization effects in the leptonic decays of hyperons $Y \to N + l^- + \bar{\nu}$ are considered. A formula is obtained for the decay probability for given polarization states of the baryons and lepton $l^-$. The longitudinal polarization and muon-baryon spin correlation coefficients are calculated explicitly. These coefficients depend strongly on the ratio of the axial and vector form-factors, however the degree of longitudinal polarization depends only weakly on this ratio. (auth)

**2441** CONSISTENCY OF THE APPROACH IN CURRENT ALGEBRA. Iwao, S. (Univ., Bern). Helv. Phys. Acta, 39: 553-5(1966).

The conserved vector current and the iso-triplet current hypotheses for the charged pion decay are used as a consistency check of the algebra of current, the partially-conserved axial-vector current and the soft-pion hypotheses and lead to the consistent result. (auth)

**2442** THE $\Sigma^+ \to p\gamma$ DECAY. Zakharov, V. I.; Kaidalov, A. B. JETP Lett. (Engl. Transl.), 4: 183-5(Oct. 1, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 4: 273-6(Oct. 1, 1966).

The imaginary amplitude of the $\Sigma^+ \to p\gamma$ decay, an amplitude connected with the existence of real intermediate states $\Sigma^+ \to n\pi^+ (p\pi^0) \to p\gamma$, was calculated. The result is discussed from three points of view: the possibility of obtaining information on the mechanism of the $\Sigma^+ \to n\pi^+$ decay from the study of the $\Sigma^+ \to p\gamma$ decay, the degree of violation of unitary symmetry in the $\Sigma^+ \to p\gamma$ decay, and the possible magnitude of the difference in the probabilities of the decays $\Sigma^+ \to p\gamma$ and $\bar{\Sigma}^+ \to \bar{p}\gamma$ in the case when CP invariance is strongly violated in strangeness-changing electromagnetic transitions. (B.G.D.)

**2443** REST MASS OF MUONIC NEUTRINO AND COSMOLOGY. Gershtein, S. S.; Zel'dovich, Ya. B. JETP Lett. (USSR) (Engl. Transl.), 4: 120-2(Sept. 1, 1966).

Translated from Eksp. Teor. Fiz., Pis'ma Redakt., 4: 174-7 (Sept. 1, 1966).

The gravitational effect of the neutrinos on the dynamics of the expanding universe is considered. No new information is found for the electronic neutrino, but for the muonic neutrino the cosmological considerations reduce the upper limit of the rest mass by three orders of magnitude. (J.F.P.)

**2444** NEUTRINO PHYSICS. Nagy, Karoly (Lorant Eotvos Univ., Budapest). Fiz. Szemle, 16: 261-5(Aug. 1966). (In Hungarian).

The energy spectrum of electrons and positrons emitted during the $\beta$ decay is continuous up to a certain maximum energy $E_{max}$. On the basis of the quantum theory, it was expected that if only one particle is generated during the process, it must possess a monochromatic energy. It appeared at first that the law of conservation of the impulse momentum is violated in this process; the apparent contradiction was explained by postulating that a neutral, zero rest-mass fermion, the neutrino is also emitted at the same time. Being a fermion, the neutrino possesses an antiparticle, the antineutrino; both are electrically neutral, have a spin of ½ and a magnetic moment of zero. In the Majorana neutrino theory it was assumed that the two particles are identical but experimental data support the Dirac theory. Of great importance for the development of the neutrino physics were the experiments carried out with free reactor neutrinos, based on the following processes: $\gamma + n \to p + e^-$; $\bar{\nu} + p \to n + e^+$. In view of the low cross section, these processes could not be observed for long time and their detection in 1956 is considered the first direct proof of the existence of the neutrino. Studies on the evaluation of the rest mass of $\mu$ neutrinos yielded results which do not contradict the assumption that $m_{\nu_\mu} \neq 0$. The ultimate rest mass of the $\mu$ neutrino may be due to an as yet unknown interaction, in which both the $\mu$ neutrino and the muon participate. (TTT)

**2445** THE POSSIBLE EXISTENCE OF $Q_K \neq 0$ PARTICLES AND THE WEAK INTERACTIONS. Itoh, C. (Tokyo Univ.). Nuovo Cimento (10), 45A: 762-4(Oct. 1, 1966).

The possible existence of large-mass vector bosons $V^\pm$, which have $Q_K = \pm 1$ and $Q_J = 0$, instead of the usual intermediate vector bosons $W^\pm$, is discussed. An interpretation is given of the nonleptonic decay of hyperons analogous to that of the leptonic weak interaction. (L.B.S.)

**2446** A NOTE ON THE ISOSPIN STRUCTURE OF THE WEAK NONLEPTONIC STRANGENESS CONSERVING INTERACTIONS. Blin-Stoyle, R. J.; Herczeg, P. (Univ. of Sussex, Brighton, Eng.). Phys. Lett., 23: 376-7(Nov. 7, 1966).

It is pointed out that the presence of an "irregular" component in the strangeness conserving hadronic current leads to an isovector part in the weak $\Delta Y = 0$ nonleptonic hamiltonian. (auth)

**2447** $K_2^0 \to \mu^+ + \mu^-$ AS A TEST OF NEUTRAL LEPTON CURRENTS. Sehgal, L. M. (Carnegie Inst. of Tech., Pittsburgh). Nuovo Cimento (10), 45A: 785-8(Oct. 1, 1966).

An estimate is given of the rate of decay $K_2^0 \to \mu^+ + \mu^-$ arising from electromagnetically induced coupling of $K_2^0$ to a neutral lepton current. (L.B.S.)

**2448** GENERALIZED LEE MODEL AND ITS APPLICATION. Chen, Fei-Shian. New Haven, Yale Univ., 1966. 98p.

Thesis.

It was found that by introducing an extra unstable $V_2$ field into the Lee model, the $V\theta$ sector of this generalized model provides a calculable model with which to study the Peierls mechanism. A W field with $W \rightleftharpoons V + \theta$ is also introduced to the model, so that one can study the renormalization of the W field for this higher order interaction. In order to obtain the various solutions, the Green's function method is applied. It was found that it provides a more straightforward way to the solution free from the ambiguities of the dispersion treatment. The solution to the $V\theta$ sector of above cases, that is (I) $V_2$ present, (II) W present was obtained. Finally, the numerical calculation of the $V\theta$ scattering and production cross sections are presented. The conclusion is that no bump is found to support the Peierls mechanism. Remarks on the extension of this work are also included. (Dissertation Abstr.)

## Strong (General)

*Refer also to abstract 2415.*

**2449** (INR-733/VII/PH) A THREE QUARK MODEL OF BARYONIC STATES WITH A NONLOCAL SEPARABLE POTENTIAL. Deloff, A. (Institute of Nuclear Research, Warsaw (Poland)). June 1966. 31p. Dep.

A nonrelativistic quark model of baryonic states is presented. The quarks interact via $SU_3$ and $SU_2$ spin invariant two and three body nonlocal separable potential. The potential contains spin and unitary spin exchange terms. The baryonic states are supposed to furnish L = 0 and L = 1 positive and negative parity multiplets. For the states of assumed symmetry the appropriate integral equations are derived and solved approximately in order to obtain the binding energies. In the case of the two body interaction the model provides the required strong binding only in states $L = 1^+$, and the states L = 0 and $L = 1^-$ are not bound unless three body forces are introduced. With three body forces it is quite easy to obtain strong binding in all states considered. (auth)

**2450** BASIC PROBLEMS IN STRONG INTERACTIONS AT VERY HIGH ENERGIES. Mur, V. D.; Rozental, I. L. pp 3-29 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The experimental bases for the fundamental principles of contemporary field theory are discussed. Fundamental length and dispersion relations, Pomeranchuk's theorem, the effective cross sections in various processes in local field theory, and the asymptotic scattering amplitude of real particles are some of the topics considered. Multiple processes are also considered in detail; the hydrodynamic, and the fireball models are discussed along with peripheral interactions. The various theories for these multiple processes are compared with the known experimental facts and the bases for the hydrodynamic theory and the fire-ball model are outlined. 70 references. (G.O.Y.)

**2451** N-QUANTUM APPROXIMATION IN STATIC MODELS. Pagnamenta, Antonio (Rutgers State Univ., New Brunswick, N. J.). Ann. Phys. (N. Y.), 39: 453-97(Oct. 4, 1966).

The N-quantum approximation (NQA) is a method designed to construct approximate operator solutions to the field equations. It is shown in detail how this method works and can be made compatible with the renormalization program in the Lee model and for the scalar field interacting with a fixed fermion source. The terminated in-field expansions can still be applied successfully in the presence of bound states, for which one will introduce new infields, or if one deals with resonances. This is discussed on the examples of the V -$\theta$-bound state and the unstable V -particle. (auth)

**2452** THE ANALYTIC S MATRIX. A Basis for Nuclear Democracy. Chew, Geoffrey F. New York, W. A. Benjamin, Inc., 1966. 111p.

A systematic presentation of strong interactions is given on the basis of the S matrix, without field theoretical ideas. Maximal analyticity of the second degree, which is equivalent to the concept of nuclear democracy and constitutes the basis for bootstrap dynamics, is the model considered. The pole-particle and branch point-threshold correspondences, and the analytic continuation of the unitarity through discontinuity formulas are introduced. The latter is recognized as providing the basis for dynamics. (J.E.P.)

## Strong (Baryon No. = 0)

*Refer also to abstract 2803*

**2453** CURRENT ALGEBRA DETERMINATION OF THE $\sigma$-MESON PARAMETERS. Furlan, G. (Univ., Trieste, Italy. Istituto Nazionale di Fisica Nucleare, Trieste, Italy); Rossetti, C. Phys. Lett., 23: 499-500(Nov. 21, 1966).

A tentative determination of the mass and width of the meson ($\sigma$) are obtained by using the requirements of saturation of sum rules derived from SU(2) × SU(2) algebra, with a limited number of single particle states. (G.O.Y.)

**2454** TWO-MESON ANNIHILATION OF BARYONS IN BROKEN SL(6,C) SYMMETRY. Winternitz, P.; Makarov, A. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 868-71(Oct. 1966). (In Russian).

The two-meson annihilation of a $p\bar{p}$ pair at rest is considered assuming the SL(6,C)-symmetry. Relations between the amplitudes and cross sections of various processes are obtained in good agreement with the experimental data. (auth)

**2455** SCATTERING PHASE SHIFTS AT HIGH ENERGIES. Higuchi, Yoshio; Machida, Shigeru (Rikkyo Univ., Tokyo). Progr. Theoret. Phys. (Kyoto), 36: 313-36(Aug. 1966).

The real and imaginary parts of the partial wave phase shifts for elastic pp, $\pi^{\pm}p$ and $\bar{p}p$ scattering are evaluated from the experimental data on the total cross section, differential cross section and the ratio of the real to the imaginary part of the forward scattering amplitude, assuming no spin dependence. In the case of $\bar{p}p$ scattering the calculated values of the ratio of the real to the imaginary part of the forward scattering amplitude are used, because there are no experimental data available. The results obtained depend mainly on the contribution of the diffraction scattering, and it is shown that the contributions from the intermediate and large angle scattering are quite small numerically. It is also shown, by examining several reasonable forms of the t dependence of the ratio of the ratio of the real to the imaginary part of the scattering amplitude, that it does not affect the results appreciably. (L.B.S.)

**2456** DYNAMICAL MODEL FOR THE MESON SPECTRUM. Chan, Hong-mo; Wilkin, C. (CERN, Geneva). Ann. Phys. (N. Y.), 39: 300-34(Sept. 1966).

A model for the meson spectrum is constructed under the following dynamical assumptions: dominance of processes with low thresholds; dominance of one-particle-exchange forces; $SU_3$ symmetry; dominance of quasi-two-particle states in production processes. A bootstrap system is sought which satisfies the following conditions: "consistency" in that all exchanged particles are bound as poles in the appropriate direct channels; "closure" in that no further low-lying states are bound other than those whose exchange contributes to the forces; "completeness" in that all "low" energy processes involving any of the particles in the spectrum are taken into account. Starting from the $0^-$ octet ($\pi$, K, $\eta$) and the $1^-$ octet ($\rho$, $K^*$, $\phi$), these consistency considerations lead to the meson supermultiplets listed. Interesting regularities in the predicted spectrum are noted. In particular one sees that apart from "Regge" recurrences, the spectrum happens to coincide with that contained in the $(6^*,6)-(6,6^*)$ representation of the recently proposed $U_6 \times U_6$ supersymmetry. A tentative assignment is attempted of known meson states into the scheme. Apart from the $K^+ - \pi^+ - \pi^0$ enhancement at 1270 MeV, all reasonably well-established resonances to date fit comfortably into the spectrum. Further empirical regularities are noted in the assignment, which includes one in the Bronzan-Low quantum number A. Wherever feasible, the dynamical parameters (masses, coupling constants) are computed by requiring numerical "bootstrap" consistency using a method proposed by Zachariasen and Zemach. These values are listed, from which it is seen that qualitative agreement is obtained for all parameters so far calculated. (auth)

**2457** EIGHT WAYS OF DETERMINING THE $\rho$-MESON COUPLING CONSTANT. Sakurai, J. J. (Univ. of Chicago). Phys. Rev. Lett., 17: 1021-4(Nov. 7, 1966).

The numerical values of the meson ($\rho$) coupling constant estimated from a variety of processes are shown to be in excellent agreement with each other. (auth)

**2458** QUARK-ANTIQUARK MODELS OF MESONS WITH RELATIVISTIC KINEMATICS. Tassie, L. J. (Australian National Univ., Canberra); Lichtenberg, D. B. Austral. J. Phys., 19: 599-605(Oct. 1966).

Mesons are treated as bound states of a quark and an antiquark. Several models are given in which the interaction between quark and antiquark is described by a potential, and the motion of the quarks is described by the Klein-Gordon equation. Different relations among the masses of mesons within a multiplet are obtained for different models. The same relation among masses obtained from nonrelativistic Schroedinger equation models can be obtained for particular Klein-Gordon equation models either among masses or among squares of masses. (auth)

**2459** ISOTOPIC-SPIN-ONE BOSON REGGE TRAJECTORIES. Cline, D. (Univ. of Wisconsin, Madison). Nuovo Cimento (10), 45A: 750-1(Oct. 1, 1966).

It is shown that the T = 1, S = 0 boson states can be classified as Regge recurrences with approximate straight-line trajectories of slope $d\alpha/dt \sim 10.8$ to 1.0) $(GeV/c)^{-2}$. In addition, the intercept at t = 0 and the slope are in good agreement with the corresponding quantities that have been deduced from analysis of charge-exchange scattering reactions with a presumed Regge $\rho$ exchange being the dominating process. (L.B.S.)

**2460** TWO-PRONG PROTON-ANTIPROTON ANNIHILATION WITH FORMATION OF A PAIR OF CHARGED MESONS. Camisassa, G.; Cimossa, P.; Jalla, E.; Wataghin, G. (Univ., Turin). Nuovo Cimento (10), 45A: 554-8(Oct. 1, 1966).

The collision of an antiproton and a proton is considered and the differential and total cross sections for the annihilation into two pions are calculated. The calculation takes into account the 2nd-order graph with an intermediate state representing the $f^0$ boson of spin 2. The results concerning $f^0$ are added to the cross sections relative to graphs considered in the earlier paper. A reasonably good agreement with the experimental data is obtained for 3 values of the incident momentum, if a convenient relativistic cut-off factor is introduced, which contains as a cut-off parameter twice the proton mass. (auth)

**2461** ON CHAINS OF RESONANCES. Dennery, P. (Faculte des Sciences, Orsay, France); Krzywicki, A. Phys. Lett., 23: 374-6(Nov. 7, 1966).

Speculations are made on dynamical relations between resonances and in particular between recently discovered heavy bosonic resonances. (auth)

**2462** STUDIES ON VECTOR MESON RESONANCES AND THE POSSIBILITY OF THREE FUNDAMENTAL FIELDS. Schechter, Joseph Michael. Rochester, N. Y., Univ. of Rochester, 1966. 146p.

Thesis.

The bootstrap approximation to the equations of dispersion theory was used to investigate a two channel model for the $1,J^{PG} = 1,1^{2-}$ state in the scattering of two pseudoscalar mesons. Approximations were made of neglecting other channels than $\pi\eta$ and $\pi\rho$, treating the $\rho$ as a stable particle, and in accordance with the bootstrap philosophy, considering a possible resonance in the scattering channel as the main contribution to the force. A self consistent solution was found giving a $\pi\eta$, $\pi\rho$ resonance at about 1 BeV, with a width of about 125 MeV. If this resonance exists and the validity of the SU(3) symmetry scheme is assumed, then it is noted that it can only belong to the isocuplet representation of SU(3). The consequences of this are discussed and the relative decay rates of the isocuplet members in the limit of exact unitary symmetry are given. The work of several authors in predicting SU(3) symmetry from a set of bootstrap equations for the scattering of pseudoscalar mesons is considered. A minor extension of this work is made and the assumption of permutation invariance seems to be vital for these proofs. With this motivation a three field permutation invariant model that has been introduced by Yamaguchi and Neville is investigated. Two conservation laws applied to linear combinations of the permutation invariant fields leads generally to U(3) invariance and in one special case to broken U(3) invariance. A model of this type may be able to account for the Cabibbo Hamiltonian in weak interactions and that the nonrelativistic introduction of spin for the fundamental fields leads generally to U(6) symmetry. Some consequences of invariance under the higher symmetry group USp(6) for the three field model are investigated. (Dissertation Abstr.)

## Strong (Baryon No. = 1)

*Rejer also to abstracts 2455 and 2509.*

**2463** (AD-634339) SPIN EFFECTS ON TRIANGLE GRAPHS. Month, Melvin (Illinois Univ., Urbana. Dept. of Physics). 1966. Contract Nonr-1834(05). 18p. CFSTI $1.00 cy, $0.50 mn.

It is shown that the triangle amplitude can be written as the scalar graph multiplied by a factor which contains only the characteristics of the external particles. In the case where the spins of the external particles are summed, their angles averaged and where only one particle wave set (that is, a set of relative orbital angular momenta among the final state particles) is retained, then this multiplicative factor is just a product of appropriate 3-momenta. The case K (+)p to K $3\pi\pi$ at 3 BeV/c is considered; and it is demonstrated that the correct inclusion of threshold factors does not diminish the effect calculated by Halpern and Watson (Phys. Rev. v131 p2674 1963). (TAB)

**2464** (AD-634340) A "SIGMA PI PI" MASS ENHANCEMENT AND A NEARBY TRIANGLE SINGULARITY. Month, Melvin (Illinois Univ., Urbana. Dept. of Physics). 1966. Contract Nonr-1834(05). 16p. CFSTI $1.00 cy, $0.50 mn.

The enhancement observed in the $(\Sigma\pi\pi)^+$ system at about 1660 MeV is described using a triangle diagram which has an intermediate state composed of a $\pi^+$ and a $Y_1^*$ (1520). In view of this, it is suggested that this enhancement does not represent the three particle decay mode of the $Y_1^*$ (1660), but that rather it is the result of a final state interaction mechanism. (auth)

**2465** EVIDENCE FOR A $P_{\frac{1}{2}}$ FINAL STATE IN $\Sigma^+ \rightarrow n + \pi^+$ DECAY. Cline, D.; Robinson, J. (Univ. of Wisconsin, Madison). Phys. Lett., 23: 509-12(Nov. 21, 1966).

The orbital angular momentum of polarized $\Sigma^+$ decay is determined by measuring the polarization of the neutron using n-p scattering as an analyzer in an H bubble chamber. On the basis of 83 n-p scatters the results of the experiment favor a $P_{\frac{1}{2}}$ state for the $\pi^+n$ system. (auth)

**2466** INELASTIC MESON–NUCLEON SCATTERING IN THE QUARK MODEL. Locher, M. P.; Roemer, H. (Univ., Bonn). Phys. Lett., 23: 496-8(Nov. 21, 1966).

Several predictions of the independent quark model with unresolved elementary mesons are derived for quasi-two-body meson-nucleon reactions. The results are compared with experiment. (auth)

**2467** ON THE DETERMINATION OF THE SPIN AND PARITY OF THE $\Omega^-$-HYPERON. Bilenkii, S. M.; Ryndin, R. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 875-80(Oct. 1966). (In Russian).

It is shown that the spin and parity of the $\Omega^-$-hyperon can be uniquely determined by analyzing the decays of $\Omega^-$-hyperons produced in the reaction $K^- + p \rightarrow \Omega^- + M_1$ ($M_1$ is a newly discovered boson with strangeness S = 2) on a polarized target. The considerations are based on invariance principles only. No assumptions are made on the dynamics. (auth)

**2468** ARE INELASTIC PION-NUCLEON INTERACTIONS AT 7.5 GeV SIGNIFICANTLY NONPERIPHERAL? Golyak, I. G.; Ruskin, V. I. (Inst. of Nuclear Physics, Kazkh SSR). Yadern. Fiz., 4: 872-4(Oct. 1966). (In Russian).

It is shown that the account of the polarization of nucleon isobars produced in a number of pole processes makes it possible to describe the experimentally observed proton momentum spectrum in the cms. (auth)

**2469** STATIC MODEL CALCULATION OF THE NUCLEON GROUND STATE. Itoh, Takashi (Toyko Univ.). Progr. Theoret. Phys. (Kyoto), 36: 342-7(Aug. 1966).

The ground state energy and eigenvector of the Chew-Low model is computed by a kind of Tomonaga intermediate coupling method, and the result is compared with those of Halpern et al. and of Drachman. The present method gives a fairly good result in spite of its simplicity. (auth)

**2470** ON THE STRUCTURE OF BARYONS. Tati, Takao; Nagai, Hideaki; Okada, Kunihiko (Hiroshima Univ.). Progr. Theoret. Phys. (Kyoto), 36: 419-20(Aug. 1966).

The structure of baryons is examined on the basis of the composite model of three fundamental triplets (fermions) of SU(3) under a number of simple assumptions and is compared with known data on nucleon levels. It is inferred that all the octet and decuplet baryons exist that have similar structure and the same spin and parity as the nucleons considered. (L.B.S.)

**2471** INDEPENDENT-PARTICLE EXCHANGE MODEL OF MESON-NUCLEON INTERACTIONS AT 7.5 GeV. Golyak, I. G.; Rus'kin, V. I. Izv. Akad. Nauk Kaz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 16-32(Apr.-June 1966). (In Russian).

An independent-particle exchange model was used for developing a generalized polar approximation of peripheral interactions considering not only the events with meson ($\pi$) exchange but other events with any definitely established non-strange, boson resonance particles. It was found that in the event of pion-nucleon interactions at 7.5 GeV a combination of polar processes from resonance particles moving at an angle close to the direction of the initial pion-nucleon interactions in the center-of-mass system ($\pi$N) or with $0.6 \leq |\cos\theta| \leq 1.0$. Tabulated data are given of the kinematic characteristics of nucleon isobars (or boson resonance particles) in the center-of-mass system ($\pi$N), momenta in MeV, the maximum $\cos\theta$ in which are concentrated the angular distributions, and the cross sections of corresponding processes in millibarns. (R.V.J.)

**2472** APPLICATION OF ADAIR ANALYSIS IN THE INVESTIGATION OF MESON-NUCLEON INTERACTIONS AT 7.5 GeV. Golyak, I. G.; Rus'kin, V. I. Izv. Akad. Nauk Kaz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 33-51(Apr.-June 1966). (In Russian).

Adair analysis was used in the investigation of pion-nucleon interactions at 7.5 GeV considering polarization of resonance

particles. Previously, it was shown that in the case of pion-nucleon interactions at 7.5 GeV there appears a combination of polar processes which form resonance particles moving at an angle close to the direction of the primary pion interactions in the center of mass system ($\pi$N) or with $0.6 \leq |\cos\theta| \leq 1.0$ (all these processes are described by the resonance case in the independent particle exchange model). Previously calculated kinematic characteristics of nucleon isobars or boson resonance particles in cms ($\pi$N) are tabulated. The experimental data are related to the secondary protons or mesons ($\pi$). Calculations were made to obtain the momentum and angular distribution of these particles in cms ($\pi$N). Calculated distribution of the secondary protons from the polarized nucleon isobar decay in cms ($\pi$N) is given in a series of diagrams. Considerations of resonance particle polarization produced a peak in the momentum proton distribution at 0.2 to 0.8 Gev/c. (R.V.J.)

**2473** CROSSED ELASTIC CUT VERSUS THREE-PARTICLE UNITARY CUT AS DETERMINANTS OF LOW-ENERGY SCATTERING. Bronzan, J. B.; Brown, R. W. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Ann. Phys. (N. Y.), 39: 335-50(Sept. 1966). (MIT-2098-205)

The relative importance of the crossed elastic cut and the three particle unitarity cut for $\pi^+$–p scattering in the charged scalar static model. This is done by comparing four approximate solutions for the scattering amplitude in which different singularities of the amplitude are retained: The Born pole and the elastic unitarity cut are present. The Born pole, the crossed elastic cut and the elastic unitarity cut are present. The Born pole and both the elastic and three particle unitarity cuts are present. The Born pole, a second pole representing the crossed elastic cut, and both the elastic and three particle unitarity cuts are present. In the channel studied all three dynamical singularities—Born pole, crossed elastic cut, and three particle unitarity cut—are attractive at low energy. It is found that for strong coupling, and particularly at higher energies, production has a decidedly greater effect on scattering than does crossing. It is also found that the coupling strength required to produce a $\pi^+$–p bound state at threshold is reduced when either the crossed elastic cut or three particle unitarity cut is present. The reductions effected by the two singularities are comparable, and about twice as much reduction occurs when both singularities are retained. (auth)

**2474** SCALAR-MESON PRODUCTION IN PION-NUCLEON COLLISION. Kikugawa, M.; Shiohara, M.; Yonezawa, M. (Hiroshima Univ.). Nuovo Cimento (10), 45A: 765-8(Oct. 1, 1966).

The production of an isosinglet scalar meson (S-meson) with mass 400 to 700 MeV in $\pi^-$ + p interactions is considered. The implication of the large NNS coupling constant derived from nucleon-nucleon scattering is examined. A comparison is made of partial-wave amplitudes for $\pi^-$ + p → S + n and $\pi^-$ + p → $\eta$ + n. (L.B.S.)

**2475** ANALYSIS OF $\pi$-N PHASE SHIFTS VIA A NEW REGGE REPRESENTATION. Abbe, W. J. (Univ. of Georgia, Athens); Nath, P.; Srivastava, Y. N. Nuovo Cimento (10), 45A: 675-88 (Oct. 1, 1966).

A phenomenological analysis is presented of the $\pi$-N phase shifts in both the $T = 1/2$ and $T = 3/2$ channels by means of a new Regge representation recently presented. It is shown that this representation, which was proved for a limited class of potentials in potential theory, and conjectured to be valid in the relativistic case, actually gives fairly good agreement with experiment when applied to relativistic problems. Graphs are presented for the $\delta_{11}$ and $\delta_{33}$ phase shifts, and a comparison to experiment is made. The resonance N(1480) is conjectured to lie on the second trajectory of the $J = 1/2$, $T = 1/2$ system, and it is shown that with this assumption, qualitative agreement with recent $\delta_{11}$ phase shift data can be obtained. (auth)

**2476** PRACTICAL FORMULATION OF THE ISOBAR MODEL. Deler, B.; Valladas, G. (CEN, Saclay, France). Nuovo Cimento (10), 45A: 559-87(Oct. 1, 1966).

The transition amplitude for the reactions of the type $\pi N \to \pi\pi N$ or $K^-p \to \pi\pi\Lambda$ were calculated for the case when the particles interact only two by two in the final state. The reference system is related to three particles. The expression obtained gives a symmetric role to the three different couplings which are possible when the particles are associated two by two. This expression constitutes a generalization of the expression for elastic scattering. The expression is applied to the isobar model and the interference between the two modes of creation is calculated so that $\pi^+ + p \to N^{*++} + \pi^0$; $\pi^+ + p \to N^{*+} + \pi^+$. (tr-auth)

**2477** PION-NUCLEON INTERACTION NEAR 2 GeV/c AND $\pi^-$-p ELASTIC SCATTERING AT 180 DEG. Minami, S. (Osaka City Univ.). Nuovo Cimento (10), 45A: 776-9(Oct. 1, 1966).

Experimental data on $\pi^-$-p scattering near 2 GeV/c are analyzed, and the possibility that a new resonant state exists with a mass $M \simeq 2190$ MeV and whose parity is opposite to that of the $N^*_\delta$ (2190) is pointed out. It is emphasized that strong energy dependence of the real part of the backward scattering amplitude, particularly a sudden change of the sign in a narrow energy region, gives important information concerning the existence of a resonant state. (L.B.S.)

**2478** COMPARISON OF $K^+$p DISPERSION RELATIONS WITH EXPERIMENT. Lusignoli, M. (Univ., Rome); Restignoli, M.; Violini, G.; Snow, G. A. Nuovo Cimento (10), 45A: 792-8(Oct. 1, 1966).

Predictions of the once-subtracted dispersion relations for the real parts of the $K^+$-p forward scattering amplitudes are presented and compared with experiment. (L.B.S.)

**2479** THE MAGNETIC MOMENT OF THE $\Sigma^+$ HYPERON. Orr, John Richie. Seattle, Univ. of Washington, 1965. 219p. Thesis.

The magnetic moment of the $\Sigma^+$ hyperon was measured by observing the rotation of its asymmetric decay distribution in a high magnetic field. The $\Sigma^+$ was produced via the reaction $\pi^+ + \rho \to \Sigma^+ + K^+$ at a laboratory momentum of 1140 MeV/c. The complete event, including the hyperon production and decay, was observed using a small spark chamber placed inside a pulsed magnet. The experiment yielded a magnetic moment of 1.50 ± 1.07 nucleon magnetons, based on a sample of 379 tightly selected $\Sigma^+$ hyperons. (Dissertation Abstr.)

## *Strong (Baryon No. ≥ 2)*

*Refer also to abstract 2455.*

**2480** MESON–NUCLEON COUPLING CONSTANTS FROM EMPIRICAL NUCLEON–NUCLEON SCATTERING. Koepp, G.; Soeding, P. (Univ., Hamburg). Phys. Lett., 23: 494-6(Nov. 21, 1966).

From a fit of the forward scattering amplitude and of the partial-wave amplitudes with $J \geq 2$ in proton-proton scattering, the following values for the vector meson-proton coupling constants are obtained: $g^2_\rho = 1.2 \pm 0.2$, $g^2_{t\omega} = 4.7 \pm 2.1$ and $g^2_{t\varphi} = 0$. (auth)

**2481** UNAMBIGUOUS PHASE-SHIFT ANALYSIS OF THE NUCLEON–NUCLEON-SCATTERING AT 23.1 MeV. Bilenkaya, S. I.; Kazarinov, Yu. M.; Legar, F.; Janout, Z. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 892-5(Oct. 1966). (In Russian).

The phase-shift analysis of NN-scattering has been carried out taking new data on the polarization correlation in np- and pp-collisions and on the asymmetry tensor element $\mathfrak{N}^{pp}_{kr}$ at 23.1 MeV into account. A unique solution with negative mixing parameter $\epsilon_1 = -4.86 \pm 1.39$ was obtained for $l_{max} = 2$. The phase-shifts are given for $l_{max} = 2$ and 3 as well as plots of the experimentally measurable quantities $\mathfrak{N}_{ss}$ for pp- and np-scattering. (auth)

**2482** ONE-BOSON-EXCHANGE MODEL IN THE Λ-N INTERACTION. Tsuge, Masayasu; Ueda, Tamotsu (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 36: 423-4(Aug. 1966).

Two types of experimental data on scattering lengths, effective ranges for $^1S_0$ and $^3S_1$ states, and total cross sections for the Λ-N interaction are examined on the basis of the OBE model, and are found to give different implications for the mechanism of the Λ-N force. (L.B.S.)

**2483** DISPERSION THEORETIC CALCULATION OF THE TWO-PION-EXCHANGE CONTRIBUTION IN NUCLEON–NUCLEON SCATTERING. II. DETAILED INVESTIGATION BY COMPARISON WITH THE OBEC AMPLITUDE. Furuichi, Susumu; Watari, Wataro (Rikkyo Univ., Tokyo. Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 36: 348-65(Aug. 1966).

Uncorrelated 2$\pi$-exchange contributions to the nucleon-nucleon scattering are investigated in detail by comparing the proper 2$\pi$ contributions with appropriate one-boson-exchange amplitudes. It is shown that (i) the isospin non-flip amplitude shows a behavior similar to the contribution from the exchange of a single (isoscalar) scalar boson, mainly owing to the effect of the (33) resonance; (ii) the behavior of the isospin flip amplitude is also very similar to that of the contribution from the exchange of a single (isovector) vector boson, and the contribution from the nucleon-pole term is dominant in this amplitude. Furthermore, the relation of the approach to the potential model is discussed, and it is shown that the two-pion-exchange process produces a strong attractive central force and a rather strong negative LS force. The LS force gives a splitting of the $^3P_J$ amplitudes roughly equal to the observed one. However, the central force seems too strong. The case of cutoff of the high momentum part of the contribution of the exchanged two

pions is also examined. By the cutoff procedure, the contribution from the 33 part is considerably suppressed, and the suppression becomes larger as the orbital angular momentum of the two nucleons becomes smaller. (auth)

# Particle Invariance Principles and Symmetries

## General

*Refer also to abstracts 2397 and 2533.*

**2484** (IC-66/102) COUPLING PROBLEM FOR U(p,q) "LADDER" REPRESENTATIONS. [PART] I. Anderson, R. L.; Fischer, J.; Raczka, R. (International Centre for Theoretical Physics, Trieste (Italy)). Aug. 1966. 21p. Dep. mn.

The results of an initial investigation of the couplings of three most degenerate representations of U(p,q) are presented. Function bases are obtained for the ladder representations by realizing the Bose operators and thus the algebra L(p,q) with differential forms. Also it is shown that these representations can be integrated to irreducible global representations of the universal covering group. As an example the Clebsch-Gordan coefficient for the coupling of two U(1,1) ladder representations are presented. The result is obtained that there is only one ladder representation in the direct product of two ladder representations. (J.F.P.)

**2485** PRODUCTSET POPULATIONS FOR REACTIONS INVOLVING PARTICLES OF ARBITRARY SPIN. Csonka, Paul L.; Moravcsik, Michael J. (Univ. of California, Livermore). J. Natur. Sci. Math., 6: 1-15(Apr. 1966). (UCRL-14854-T).

The number of bilinear combinations of form factors in each productset is determined for a reaction involving particles of arbitrary spin, for various situations in which rotation invariance alone, or rotation and reflection invariance, or rotation and time reversal invariance, or rotation, reflection, and time reversal invariance hold, or in the case where we have invariance under rotation and under the product of space and time reflections. (auth)

**2486** REORDERING OF BIQUADRATIC SCALARS. Frahm, Charles P. (Georgia Inst. of Tech., Atlanta). Ann. Phys. (N. Y.), 40: 159-78(Oct. 17, 1966).

A theorem analogous to the Fierz reordering theorem for Lorentz scalars constructed from 4 Dirac spinors is proven for all semisimple compact groups. The proof of the theorem depends on only 4 factors, the most important of which are the reality of the generalized Clebsch-Gordan coefficients for semisimple groups and the uniqueness of the construction of a scalar from a representation of a compact group and its contragradient. The reordering matrix associated with the scalars formed from four "octets" of SU(3) is also given along with an orthogonal matrix that diagonalizes the octet-reordering matrix. (auth)

**2487** POINCARE INVARIANCE, PARTICLE FIELDS, AND INTERNAL SYMMETRY. Feldman, G.; Matthews, P. T. (Imperial Coll. of Science and Tech., London). Ann. Phys. (N. Y.), 40: 19-45(Oct. 17, 1966).

Following Weinberg, the use of finite nonunitary representations of a noncompact auxiliary group is developed to construct local fields, corresponding to particles which belong to infinite unitary representations of the Poincaré group. It is shown how these auxiliary groups are extended to form a basis for theories such as $\tilde{U}(12)$, which can be used to build additional restrictions into a theory, without actually extending the invariance beyond the outer product of the Poincaré group with the internal symmetry group. This is done in a covariant manner, which preserves crossing symmetry and CTP invariance, although the restrictions imposed refer physically to the static limit. (auth)

**2488** "UNIQUE PROPAGATOR" FOR MESONS WITH SPIN 2,1, AND 0 IN SYMMETRY THEORIES. Ti, Kao (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 846-9(Oct. 1966). (In Russian).

The propagators for particles with spins 2, 1, 0 are obtained with the help of symmetry theory. It is shown that these propagators can be united in a "unique propagator" if the considered particles belong to the same representation. This is a new result that occurs only in symmetry theory. Projection operators must be introduced in order to obtain a propagator for a particle with a definite spin from the "unique propagator." (auth)

**2489** EIGHTFOLD-WAY FORMALISM IN SU(3) AND 10- AND 27-PLETS. Ogievetskii, V. I.; Polubarinov, I. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 853-61(Oct. 1966). (In Russian).

A vector (eightfold-way) formalism in the SU(3)-symmetry is developed in which the octets are represented in terms of a one-index quantity, whereas the 10- and 27-plets by two-index tensors. A complete set of $8 \times 8$ matrices is constructed and a number of relations in the algebra of these matrices was obtained. (auth)

**2490** NON-COMPACT INTRINSIC SYMMETRY GROUPS AND MANY-PARTICLE STATES. Hertel, P. (Univ., Heidelberg). Z. Phys., 197: 197-206(1966).

It is argued that a non-compact group describing an intrinsic symmetry of elementary particles should possess the following property: There exists a subset $\Phi$ of all the unitary irreducible representations such that for any two representations of $\Phi$ the Kronecker product decomposes into a direct sum of representations of $\Phi$ only. By this criterium the groups SL(n,C) are excluded. The coupling of unitary irreducible representations of SU(1,1) to those of the discrete series is calculated explicitly and the existence of two sets $\Phi$ is demonstrated. (auth)

**2491** ANALYTIC CONTINUATION OF GROUP REPRESENTATIONS. III. Hermann, Robert (Argonne National Lab., Ill.). Commun. Math. Phys., 3: 75-97(Sept. 28, 1966).

The connection between the ideas of "contraction" and "analytic continuation" of Lie algebras and their representations is discussed, with particular emphasis on the contraction of the Poincaré to the Galilean group. (auth)

**2492** BRANCHING DIAGRAM FOR SPECIAL UNITARY GROUP SU(n). Yamazaki, Masatoshi (Kanazawa Univ., Japan). J. Phys. Soc. Japan, 21: 1829-32(Sept. 1966).

Rules for constructing the branching diagram for special unitary group with arbitrary dimension are given. Guided by these rules diagrams for three and four dimensional groups are constructed and presented. (auth)

**2493** TENSOR PRODUCTS OF IRREDUCIBLE UNITARY REPRESENTATIONS OF THE POINCARE GROUP. Rideau, G. (Institut Henri Poincare, Paris). Ann. Inst. Henri Poincare, Sect. A, 3: 339-62(Oct. 1–Dec. 31, 1965). (In French).

The reduction of the tensor product of two irreducible unitary representations of the Poincaré group is treated. Only physical representations are considered: real mass, positive or null, $p_0 > 0$, and finite spin. (J.F.P.)

**2494** DISPERSION RELATIONS AND HIGHER SYMMETRIES. Fubini, S. (Stanford Univ., Calif. Univ. of California, Los Angeles); Segre, G.; Walecka, J. D. Contract AF 49(638)-1389. Ann. Phys. (N. Y.), 39: 381-434(Oct. 4, 1966).

A dispersion approach is employed to obtain a covariant formulation of higher symmetry groups. This is done by studying the commutation relations of the 144 generators of compact U(12) in the framework of a quark model. The generators (or generalized charges) are classified in a covariant manner and the problem of the convergence of the sum rules obtained from the commutators is analyzed. It is found that only some of the charges may be viewed as approximate constants of the motion, that is to say their off-diagonal matrix elements have a gentle high energy behavior and the corresponding dispersion sum rules converge. The above mentioned "good" charges coincide with those of the collinear SU(6) group. In this way a covariant derivation of SU(6)W is found; inserting in the sum rules the baryon $\frac{1}{2}^+$ octet and $\frac{3}{2}^+$ decuplet, some of the consequences of SU(6)W symmetry are reproduced. The matrix elements of our "good" charges can be related to scattering amplitudes of pseudoscalar and vector particles, and thereby an estimate of the limits of validity of the group symmetry is obtained. (auth)

**2495** RELATIONS BETWEEN COUPLING CONSTANTS OBTAINED FROM CHIRAL $SU_3 \times SU_3$ CURRENT ALGEBRA. Humble, S.; Poole, F. (Science Labs., Durham, Eng.). Nuovo Cimento (10), 45A: 758-61(Oct. 1, 1966).

The method of obtaining sum rules in chiral $SU_3 \times SU_3$ current algebra is extended to include coupling strengths which are not associated with the spin-zero pseudoscalar meson octet. (L.B.S.)

**2496** ON THE REPRESENTATIONS AND COUPLING OF THE $U_{6,6}$ TOWER. Akyeampong, D. A. (IAEA, Trieste, Italy). Nuovo Cimento (10), 45A: 712-20(Oct. 1, 1966).

Some representations of $U_{(\nu,\nu)} \otimes U_{(\nu,\nu)}$ are constructed and the eigenvalue problem involved in the approach is solved and shown to lead, under suitable boundary conditions, to a discrete spectrum. The coupling of the different $U_{(\nu,\nu)}$ rungs of the tower is also discussed. (auth)

**2497** EXTENSION OF HILBERT SPACE APPLIED TO INEXACT SYMMETRIES. Katz, A. (Weizmann Inst. of Science, Rehovoth, Israel). Nuovo Cimento (10), 45A: 721-4(Oct. 1, 1966).

It was previously pointed out by Fabri and Picasso that a generator $Q = \int g(x)d^3x$ cannot be an operator of Hilbert space and that

the state $1Q> = Q|0>$ cannot be a vector of Hilbert space unless $1Q> = 0$ (and in that case, the symmetry turns out to be exact). It is shown how states such as $1Q>$ may exist in a topological vector space larger than the Hilbert space, giving meaning to the manipulations customary in theories of inexact symmetries. Unbounded operators are also rehabilitated in the new space. (L.B.S.)

## Applications (Electromagnetic and Weak)

**2498** RADIATIVE DECAY OF $1^+$ MESONS AND UNITARY SYMMETRY. Duc, Dao Wong (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 843-5(Oct., 1966). (In Russian).

A general expression is given for the radiative decay probability of $1^+$ mesons. Relations between widths are presented in the unitary symmetry scheme, under various assumptions on the unitary multiplets to which the mesons belong. (auth)

**2499** ELECTROMAGNETIC INTERACTION OF THE X-MESON IN HIGHER SYMMETRIES. Bokov, O. G.; Nguyen Van Hieu; Sredniava, B. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 850-2(Oct. 1966). (In Russian).

Radiative decays of the ninth pseudoscalar meson X(960) are treated. Relations were obtained between the coupling constants for single photon decays of the X-meson and the nonet of vector mesons and for the two-photon decays of the pseudoscalar meson nonet in the intrinsically broken $\tilde{U}(12)$-symmetry scheme. Branching ratios were calculated. (auth)

**2500** SATURATION OF $U_3 \otimes U_3$ ALGEBRAS AT INFINITE MOMENTUM AND FINITE MOMENTUM TRANSFER. Oehme, R. (IAEA, Trieste, Italy). Nuovo Cimento (10), 45A: 664-74(Oct. 1, 1966).

The saturation of the current algebras of chiral and collinear $U_3 \otimes U_3$ is explored. The set of states consists of the octet and the decimet of baryons. The matrix elements of the commutators of current densities with the corresponding charges are evaluated at infinite momentum and finite, orthogonal momentum transfer. In the case of collinear $U_3 \otimes U_3$, the infinite momentum is parallel to the direction specified by the algebra. The results are the same for both algebras. They are not consistent with those obtained from collinear $U_6$ symmetry. In particular, the f- and d- components of the Pauli magnetic form factors vanish for all values of $q^2$, and the vector part of the decimet-octet transition matrix element is zero at $q^2 = 0$. The problem of admixtures is discussed briefly. (auth)

**2501** RADIATIVE DECAYS OF VECTOR MESONS IN $SU_6$. Chan, F. C. (Ohio State Univ., Columbus). Nuovo Cimento (10), 45A: 747-9(Oct. 1, 1966).

The decays of the $J^P = 1^-$ vector mesons into two pseudoscalar mesons and one photon are studied from the point of view of $SU_6$. Results are obtained for the decay amplitudes, which are good only in the $SU_6$ limit when the decays proceed by electric-dipole transitions. (L.B.S.)

**2502** SU(6) AND NONLEPTONIC WEAK INTERACTIONS. II. Kato, Masataka (Tokyo Inst. of Tech.). Progr. Theoret. Phys. (Kyoto), 36: 373-9(Aug. 1966).

Under the assumption of SU(6) symmetry, relations between the $\Delta I = 3/2$ amplitudes of the hyperon nonleptonic decay are investigated. The following results are obtained for the p-wave amplitudes and s-wave amplitudes: $\Delta b(\Xi) = (1/2\sqrt{3})\Delta b(\Omega)$, $9\Delta b(\Lambda) - 10\Delta b' + (45/\sqrt{6})\Delta b(\Sigma) + 14\Delta b(\Xi) = 0$, $\Delta a(\Xi) = 0$, where the $\Delta b$'s and $\Delta a$'s are the deviations from the $\Delta I = 1/2$ rule for the p-wave and s-wave amplitudes, respectively and $\Delta b'$ is the deviation from the relation which was previously derived. If it is further assumed that the weak interactions are the lowest perturbation of 4-body quark type, relations for the s-wave and p-wave amplitudes are obtained. (auth)

**2503** STUDIES ON INVARIANCE PRINCIPLES IN ELEMENTARY PARTICLE PHYSICS AND PROTON-PROTON BREMSSTRAHLUNG. Ueda, Yoshiaki. (Rochester, N. Y., Univ. of Rochester, 1966). 123p.

Thesis.

The testing and application of invariance principles is discussed. The effects of time reversal invariance violation in $K \rightarrow 3\pi$ decay was investigated. In a linear energy approximation for the decay matrix elements, it can be proven using the TCP theorem alone that the partial decay rate of the $\tau$(or $\tau'$ or $\theta$) mode for the $K^+$ meson is nearly equal to that for the $K^-$ meson, provided that contributions from the final state I = 3 pion configuration can be neglected. Also, effects of final state pion-pion interactions are computed by extending the dispersion-theoretical treatment of Khuri-Treiman. Next as an application of invariance principles a general theory of relativistic angular correlations for successively decaying particles is developed. Relativistic invariance is guaranteed by the use of the helicity formulation. As examples, the $\Xi$ and $\Sigma^0$ are investigated in detail. The proton-proton bremsstrahlung is also investigated by using a field theory as opposed to a potential model. The one pion exchange model is adopted and part of the matrix element is related to the photopion production matrix element, which is expressed in terms of dispersion relations. A detailed analysis shows that the Born approximation diagrams give the dominant contribution and that the diagrams involving $N^*$ or $\rho$ resonances are negligible for the energy considered. It was found that the results, unlike those of the potential model, seem to give satisfactory agreement with experimental data. (Dissertation Abstr.)

**2504** UNITARY SYMMETRY AND WEAK INTERACTIONS. Rosen, S. P. (Purdue Univ., Lafayette, Ind.). 21p. (CONF-660545-3). ORAU. Gmelin, AED-CONF-66-140-3.

From Midwest Conference on Theoretical Physics, Bloomington, Ind.

The symmetry aspects of weak interactions are investigated; in particular, the problem of determining the transformation properties for semileptonic and nonleptonic processes are examined. It is shown how the vanishing asymmetry parameters in $\Sigma^+ \rightarrow n\pi^+$ can be used to make predictions which depend neither upon octet transformation properties nor upon the current × current hypothesis. (L.B.S.)

## Application (Strong)

*Refer also to abstracts 2462 and 2803.*

**2505** UNITARY SYMMETRY CLASSIFICATION OF THE $\Xi^*$(1810 MeV). Engelbrecht, C. A. (Atomic Energy Board, Pretoria). Tydskr. Natuur., 5: 185-7(Nov.-Dec. 1965).

The new 1810 MeV $\Xi^*$ resonance can be fitted into the unitary symmetry classification scheme in three plausible ways. Consequences of and arguments against each of these possibilities are presented. Further experiments are suggested to decide between them. (auth)

**2506** QUARK MODELS, UNIVERSALITY, SYMMETRY, AND HIGH-ENERGY SCATTERING. Levinson, C. A. (Univ. of Maryland, College Park); Wall, N. S.; Lipkin, H. J. Contract AT (40-1)-3491. Phys. Rev. Lett., 17: 1122-5(Nov. 21, 1966).

New relations between meson-baryon and baryon-baryon cross sections are found by making use of predictions for scattering on deuteron targets. These are in better agreement with experiment than previously derived relations and provide a better parametrization for the quark-model amplitudes. They show that universal coupling of $\omega$ and $\varphi$ Regge trajectories to mesons and baryons is a good approximation, but that the ratio of the two couplings is about 20% greater than predicted by SU(3) and SU(6). (auth)

**2507** M(12) AND VECTOR-MESON PRODUCTION AT HIGH ENERGY. Hosoda, Masataka; Yamamoto, Kunio (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 36: 366-72(Aug. 1966).

A method used previously for discussion of the bump behavior of the differential cross section near the forward direction is applied to the vector meson production. It is assumed that, for the forward amplitudes, M(12) is broken in such a way that at high energy the contributions from intermediate states with parity $(-1)^{J+1}$ in the t channel are suppressed for some reason in comparison with those from the states with parity $(-1)^J$, J being the total angular momentum. M(12) is used only for the calculation of the ratios of the helicity amplitudes in the forward direction. Bump-behavior is expected for almost all vector meson production processes. The results are consistent with experiments. (auth)

**2508** ON THE BARYON MASS LEVEL. Yamazaki, Masatoshi (Kanazawa Univ., Japan). J. Phys. Soc. Japan, 21: 1629-33(Sept. 1966).

With the assumption that baryon resonance mass differences are mainly attributed to kinetic energy differences and partly to spin orbit coupling perturbations, the baryon resonance mass level pattern for unitary octets, decuplets, and singlets with various spin and parity values is estimated by classification with symmetric group of degree three and compared with experimental data. Reasonable agreement indicates the assumption may be reasonable. It is assumed that the over-all wave function is totally symmetric and the internal (vibrational) wave function is also totally symmetric for permutation. (auth)

**2509** SU(3) ASSIGNMENT AND COUPLING OF $N^*(1688)$. Heusch, C. A.; Prescott, C. Y.; Dashen, R. F. (California Inst. of Tech., Pasadena). Phys. Rev. Lett., 17: 1019-21(Nov. 7, 1966).

A comparison of the reactions $\gamma + p = \eta + p$ and $\gamma + p = \pi^0 + p$ in the region of the third nucleon isobar $N^{***}(1688)$ gives evidence that $N^{***}$ (1688) is a member of a unitary octet and that the D/F ratio, which relates the couplings $N^{***}N\pi$ and $N^{***}N\eta$, is similar

to that which relates the couplings $NN\pi$ and $NN\eta$. The invariant coupling ratio $\gamma N^{***}\ N\eta/\gamma N^{***}\ N\pi^0$ is plotted versus the D/F coupling parameter. (J.F.P.)

**2510** NON-INVARIANCE GROUPS AND STRONG COUPLING MODELS. Mukunda, N. (Princeton Univ., N. J.). 15p. (CONF-660540–7). ORAU. Gmelin, AED-CONF-66-113-6.

From Conference on Non-Compact Groups in Particle Physics, Milwaukee.

The idea of the noninvariance group of a dynamical system is reviewed briefly for the nonrelativistic three-dimensional hydrogen atom. The problem of constructing the noninvariant generators of the group G is then applied to elementary particles; first within the static strong coupling meson theory, and then to the case of the unitary symmetric pseudoscalar theory. Predictions of the theory for meson-baryon scattering are discussed. (L.B.S.)

## Quantum Field Theories

*Refer also to abstracts 2450, 2487, and 2535.*

**2511** (UCRL–17139) STRUCTURAL INCONSISTENCY OF THE QUANTUM ELECTRODYNAMICS OF HIGHER SPIN FIELDS. Sharefkin, Mark Frank (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1966. Contract W-7405-eng-48. 72p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Thesis.

A structural classification of Duffin-type Lagrangians serves to introduce several simple consistency conditions, and motivates the construction of an aberrant vector theory structurally similar to boson theories of spin ≥ 2. The corresponding minimal electrodynamics is shown to violate microscopic causality: any nonzero coupling generates terms in the equal-time self commutator of the charge density operator which are nonzero outside the light cone. The requirement that this commutator be local is therefore a nontrivial restriction on the Lagrangian, and it is not obvious that a spin-2 Lagrangian consistent with this requirement can be found. (auth)

**2512** GENERATING FUNCTIONAL FOR GENERALIZED RETARDED OPERATORS. Syed, Ansaruddin (Univ. of Karachi, Pakistan). J. Natur. Sci. Math., 6: 105-10(Apr. 1966).

A generating functional is obtained for an important subset of the set of all the generalized retarded operators. In the particular case of ordinary retarded and advanced products, it reduces to the well known LSZ generating functional. (auth)

**2513** INTERACTION PICTURE. Guenin, Marcel (Princeton Univ., N. J.). Commun. Math. Phys., 3: 120-32(Sept. 28, 1966).

It is shown that the difficulties connected with Haag's theorem can be bypassed, without losing Euclidean invariance, if the time evolution is considered as being only locally unitarily implementable. A variant of the conventional interaction picture is defined, and a perturbation expansion derived which is shown to converge absolutely for a class of (nontrivial) Euclidean invariant 2-dimensional models. (auth)

**2514** NONRENORMALIZABLE FIELD THEORIES. Halpern, M. B. (Univ. of California, Berkeley). Ann. Phys. (N. Y.), 39: 351-75(Sept. 1966).

A large class of nonrenormalizable field theory models is studied in the Bethe-Salpeter framework. In particular, those cases are discussed for which the kernel in Euclidean space is a singular potential. The conclusions are as follows: (1) Although the solutions obtained in Euclidean space solve their integral equations rigorously, the functions obtained from them in Minkowski space by undoing the formal rotation do not solve the original (Minkowski space) integral equations in any ordinary (including distribution theoretic) sense. This happens because the formal Euclidean rotation is around an essential singularity (on the light cone). (2) There are two "senses," in which these Minkowski space "solutions" can be said to satisfy their integral equations: The solutions can be obtained as regulator limits. Equivalently, the solutions can be obtained if one redefines the integration path in the equations and makes an illegal interchange of integration order. (3) Because such (nonaxiomatic) intermediate steps are actually involved in obtaining these solutions, it turns out that each of the final solutions contains violation of axiom (usually positive-definiteness of probability). (4) There seems to be little or no relation between nonrenormalizable field theory and singular potential theory, as the connection between the two (rotation between Euclidean and Minkowski space) always involves implicitly, as stated in (1), (2), either regulator limits or illegal interchange of integration order and, as stated in (3), always leads to violation of axiom in Minkowski space. (auth)

**2515** SOME REMARKS ON THE FIELD THEORY FOR HIGHER SPIN. Chang, Shau-jin (Harvard Univ., Cambridge, Mass.). Phys. Rev. Lett., 17: 1024-7(Nov. 7, 1966).

The field theory for higher spin proposed by Tung is examined. It is shown for $S \geq 3/2$ that this theory describes a system which is the superposition of two spin-S fields with opposite parities. The energy of this system is no longer positive definite. Possible alterations of the theory are discussed. (auth)

**2516** COMMUTANTS OF CERTAIN OPERATOR ALGEBRAS ON FOCK SPACE. Kastler, D.; Sirugue, M.; Trotin, J. C. (Argonne National Lab., Ill. Univ., Aix-Marseille, France). Ann. Inst. Henri Poincare, Sect. A, 4: 77-82(Jan. 1–Feb. 15, 1966).

H. Ekstein recently proposed to replace the usual assumptions on invariance under a group of internal symmetries by a simple postulate on the commutant of the S matrix. A theorem is proposed and proved in order to accomplish this. (B.G.D.)

**2517** STUDY OF TENSOR AND SPINOR PROPAGATORS. Colleau, Jean. Ann. Inst. Henri Poincare, Sect. A, 3: 195-337 (Oct. 1–Dec. 31, 1965). (In French).

A study is made of how tensor-spinor propagators of any order of the scalar propagator or at least of first orders can be deduced. This property is only extended to the terms in front of the propagators for the general case. A more complex rule is obtained for diffusion terms, and it is examined by means of a simple approximation on a quasi-Minkowskian space-time. (J.F.P.)

**2518** VANISHING RENORMALIZATION CONSTANTS AND SPONTANEOUS GENERATION OF SYMMETRIES. Bludman, S. A. (Univ. of Pennsylvania, Philadelphia); Deshpande, N. G. Nuovo Cimento (10), 45A: 654-64(Oct. 1, 1966).

Dynamical origin of symmetries in potential problems has recently received a great deal of attention. It is pointed out that there exists a soluble model in quantum field theory, namely the Ruijgrok-Van Hove model, where the solutions possess a higher symmetry than apparent in the original hamiltonian. The symmetries arise due to the dynamics and are exact only in the limit of vanishing renormalization constants. Thus the model illustrates how the bootstrap principle applied to field theory can generate symmetries spontaneously. The role played by inequivalent transformation in symmetry generation as is the case in the spontaneous symmetry breakdown is also shown. (auth)

**2519** THE SOLUTION OF THE SCHROEDINGER EQUATION AND THE WAVE OPERATORS IN THE V$\Theta$–N$\Theta\Theta$ SECTOR OF THE LEE MODEL. Tindle, G. L. (Univ. of Birmingham, Eng.). Nuovo Cimento (10), 45A: 619-40(Oct. 1, 1966).

The exact solution of the Schrödinger equation is obtained in the V$\Theta$–N$\Theta\Theta$ sector of the Lee model with a finite-volume system of infinite heavy fermions and relativistic mesons. The resolution of the identity, $P_\lambda$, associated with the total Hamiltonian, H, and the free Hamiltonian, $H_0$, is put into a form which is suitable for studying the infinite-volume limit. A simple formula is then derived, expressing the weak limit, $W_+ = w\text{-}\lim_{t\to-\infty} \exp[iHt]\exp[-iH_0t]$, in terms of $P_\lambda$. The existence of the strong limit is investigated and a unitary operator, $\Omega_+$, constructed with the intertwining property, $H\Omega_+ = \Omega_+H_0$. The S-matrix is obtained and found to be the same as that previously given in the literature. In an Appendix, a method of evaluating a typical integral, occurring in the investigation of the strong limit, is discussed which may be useful in other approaches to the three-body problem. (auth)

## Scattering Theory

*Refer also to abstracts 2394 and 2397.*

**2520** PADE APPROXIMANTS AND BOUNDS ON THE BETHE–SALPETER AMPLITUDE. Nuttall, J. (Texas A and M Univ., College Station). Phys. Lett., 23: 492-4(Nov. 21, 1966).

Non-relativistic scattering theory methods are generalized to apply to the Bethe-Salpeter equation as treated by Schwartz and Zemach. Lower bounds to the phase shifts are given and the convergence of the sequence of {N,N} Padé approximants is proved. The {1.1} Padé approximant provides a reasonable approximation for a range of values of the coupling constant. (auth)

**2521** FACTORIZATION OF THE S MATRIX OF SCHROEDINGER'S MULTIDIMENSIONAL OPERATOR. Faddeev, L. D. (Steklov Inst. of Mathematics, Leningrad). Dokl. Akad. Nauk SSSR, 167: 69-72(Mar. 1, 1966). (In Russian).

Certain formulas in dispersion theory are generalized for the multidimensional case which, in the one dimensional case, are well known solutions of the Schroedinger equation. The work is an extension of earlier work on the inverse problem in dispersion theory. This is the problem of finding the physical potential v(x) from the S-matrix. The generalized analog to the one-dimensional S-matrix

factorization equation is developed and the limitations of the possible solutions are discussed. Other developments along parallel lines are reviewed, and the change of notation from other authors is considered in unifying the discussion. The present generalization of the factorization equation differs from the findings of H. E. Moses, and the formalism of the inverse dispersion problem developed by I. Kay and H. E. Moses is found to be erroneous. (TTT)

**2522** PARTIALLY CONNECTED FADDEEV-WEINBERG-ROSENBERG EQUATION. Tsukamoto, Tatsuo (Kyoto Univ.). Progr. Theoret. Phys. (Kyoto), 36: 337-41(Aug. 1966).

In order to give a foundation to the cluster approximations, the Faddeev-Weinberg-Rosenberg formalism is applied. The general partially connected integral equation is obtained. This equation is not fully connected, so it is in general not solvable. Nevertheless, it may be useful for examining and/or introducing approximations. (auth)

**2523** BEHAVIOR OF MASSES AND COUPLING CONSTANTS IN TWO PROCESSES INVOLVING VANISHING $Z_3$. Kinoshita, Kisei (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 36: 380-93(Aug. 1966).

The processes of taking the limit of vanishing $Z_3$ are investigated without any restriction on the number of particle states and free parameters in a single channel. These limiting processes are classified into two kinds, according to whether the scattering amplitude goes into its one-particle irreducible part or not. The former process is understood to be the decoupling limit of the interaction of a bare field which appears in the one-particle intermediate state, and the latter to be the direct interaction limit of the propagation of the bare field. For the many-pole amplitude with a finite bare mass, a one-to-one correspondence is obtained between the physical particle poles and the set consisting of pseudo-particle poles plus a bare particle. In the former process involving vanishing $Z_3$, a physical particle pole tends to the bare field with the interaction switched off and the other physical particle poles tend to corresponding pseudo-particle poles. In the latter process, the bare mass tends to infinity and the information about the bare field remains in the form of a direct interaction. Any amplitude can be regarded as obtained from another one by these limiting processes. This fact implies an ambiguity in separating an amplitude into the modified Born term and the one-particle irreducible part. (auth)

**2524** COMPARISON OF THE FORMAL THEORY OF SCATTERING WITH THE CHANNEL APPROACH. Dolinszky, Tamas. Magyar Tud. Akad. Kozp. Fiz. Kut. Int. Kozlem., 14: 287-97(1966). (In Hungarian).

The scattering amplitude is defined by analytical expressions formulated differently in terms of the theory of scattering and in terms of the channel approach. The comparison of the analog concepts shows that the transition matrix element of the formal theory of scattering is fully reproduced by the collision matrix element of the channel approach in the case of elastic scattering by a finite range central force. For nuclear reactions the matrix elements are seen to differ even for two-nucleon interactions of finite range. The difference between the two matrix elements is presented in an analytical form, and it is shown to be due to the presence of polarization forces in the external region. (auth)

**2525** MANY-CHANNEL GEL'FAND-LEVITAN EQUATIONS. Cox, Joseph R. (Florida Atlantic Univ., Boca Raton). Ann. Phys. (N. Y.), 39: 216-36(Sept. 1966).

The method of Gel'fand and Levitan for the construction of a spherically symmetric potential in the Schrödinger equation from a spectral function which contains scattering and bound-state data for a single angular momentum state is extended to include the case of n channels coupled by a potential matrix, all of whose elements possess finite first and second absolute moments. The utility of the method for the explicit construction of many-channel S-matrices together with the associated interaction potentials is illustrated by two simple examples. (auth)

**2526** KINEMATICS OF SCATTERING AND DECAY PROCESSES. Nyborg, Per (Agricultural Coll. of Norway, Vollebekk). Amer. J. Phys., 34: 932-7(Oct. 1966).

The kinematics of processes involving four different particles is discussed. The boundaries of the physical region for the various processes are established one at a time, using explicitly energy and momentum conservation. Then follows a joint description of all processes where all four-momenta formally are considered to be ingoing. The description is given explicitly in terms of two independent variables (s,t), in contrast to the usual symmetric (s,t,u) description. (auth)

**2527** TWO-PARTICLE OFF-SHELL EQUATIONS FOR NEGATIVE ENERGIES. Kowalski, K. L. (Case Inst. of Tech., Cleveland). Nuovo Cimento (10), 45A: 769-71(Oct. 1, 1966).

Some of the methods developed previously for studying the structure of the off-shell amplitudes at positive parametric energies are applied to the negative-energy case. The off-shell-partial-wave amplitudes are expressed in terms of "reduced" amplitudes, which are free of bound-state pole singularities. A framework is provided for constructing separable approximations to the negative-energy off-shell amplitudes. (L.B.S.)

**2528** SOME REMARKS ABOUT THE ASYMPTOTIC BEHAVIOR OF THE PARTIAL-WAVE AMPLITUDE FOR LARGE ANGULAR MOMENTA IN POTENTIAL SCATTERING. Bertero, M. (Univ., Bonn). Nuovo Cimento (10), 45A: 740-6(Oct. 1, 1966).

Some remarks are made about previous results obtained by the Lippmann-Schwinger equation and the Smithies theory of Fredholm integral equations for the asymptotic behavior of the partial-wave amplitude. An improvement of the method is presented, and it is found that for a Yukawa potential the partial wave amplitude $A(-i\nu,k)$ $(\lambda = -i\nu)$ tends to zero, $\nu \to +\infty$, uniformly in $k \in [0, +\infty]$. The result is new and implies restrictions on the location of the Regge poles. (L.B.S.)

**2529** NORMAL THRESHOLD BEHAVIOR IN THE PRESENCE OF ANOMALOUS THRESHOLDS. Boyling, J. B. (Univ. of Cambridge, Eng.). Nuovo Cimento (10), 45A: 706-11(Oct. 1, 1966).

An inelastic scattering amplitude is discussed which has an anomalous threshold on the physical sheet below its lowest (two-particle) normal threshold. Assuming extended unitarity, analyticity, and certain physical sheet properties of the amplitude, it is shown that its lowest normal threshold must be two-sheeted. (auth)

**2530** NONFORWARD DISPERSION RELATIONS AND THE ALGEBRA OF CURRENT COMMUTATORS. Fubini, S. (Stanford Univ., Calif. Univ., Turin); Segre, G. Nuovo Cimento (10), 45A: 641-54(Oct. 1, 1966). (UCRL-16755).

A general relation between the integral over energy of the discontinuity of a scattering amplitude and a form factor, obtained from the algebra of current commutators, is discussed. The relation is analyzed as a function of (momentum transfer)$^2$ t and of the external masses. It is shown how the high-energy part of the discontinuity generates the singularities in t of the form factor and also how, when the external masses are those of strongly interacting particles, the relation reduces to a purely strong-interaction condition. The case of isotopic-spin currents is discussed in detail and illustrations involving spin-zero and spin-one-half particles are given. (auth)

**2531** UNITARITY EQUATIONS FOR THREE-PARTICLE SCATTERING. Pearson, D. B. (Univ. of Hull, Eng.). Nuovo Cimento (10), 45A: 607-18(Oct. 1, 1966).

Bound-state amplitudes for three-particle scattering are defined in terms of the residues of the poles of a single Green's function. Unitarity equations are derived from the Hilbert relation for this Green's function. (auth)

**2532** THE STRONG UNITARITY CONDITION OF THE S-OPERATOR. Chen, Tuan-Wu (Syracuse Univ., N. Y.). Nuovo Cimento (10), 45A: 533-52(Oct. 1, 1966).

The power of the Bogoliubov causality condition is further employed to show that the strong-unitarity condition of the S-operator off the mass shell follows from weak unitarity together with the other assumptions of the theory. (auth)

**2533** REGGE POLES AND/OR GROUP THEORY? Levy-Leblond, J.-M. (Univ. of Rochester, N. Y.). Nuovo Cimento (10), 45A: 772-5(Oct. 1, 1966).

Various attempts to establish connections between complex angular momentum or Regge-pole theory and group theory are reviewed according to four categories: local representations of the rotation group; relativistic partial-wave analysis in crossed channel; complex Poincaré group; and field theory of the Poincaré group. (L.B.S.)

**2534** ESSENTIAL SINGULARITIES OF SCATTERING AMPLITUDES. Yndurain, F. J. (Univ. of Zaragoza, Spain). Nuovo Cimento (10), 45A: 789-91(Oct. 1, 1966).

It is pointed out that the fact that the scattering amplitude for a process $A + B \to C + D$ is meromorphic in s (except for cuts) and polynomial-bounded at infinity, implies that the poles of A(s,t) must be located in a bounded domain of the complex s-plane and that they cluster around certain points, $s_\gamma^{(j)}$, that are essential singularities of A. (L.B.S.)

**2535** IMPENETRABLE LINE OF SINGULARITIES OF THE SCATTERING AMPLITUDE IN POTENTIAL THEORY. Shieh, Shuang-Yuan. College Park, Md., Univ. of Maryland, 1966. 55p. Thesis.

A natural boundary or an impenetrable line of singularities across which analytic continuation is impossible is found on the second Riemann sheet of the scattering amplitude in quantum field theory. The same question is explored in potential theory with the

purpose of finding the characterization of potentials which will divide potentials into two classes: in the first class there is no natural boundary, and in the second class there exists an impenetrable line of singularities. (B.G.D.)

**2536** HOMOLOGY AND FEYNMAN INTEGRALS. Hwa, Rudolph C.; Teplitz, Vigdor,L. The Mathematical Physics Monograph Series. New York, W. A. Benjamin, Inc., 1966. 341p.

Homology theory is applied to the analytical structures of Feynman and unitary integrals. A summary is given of the principal achievements of the study of the analyticity of Feynman integrals by classical methods. The geometric problem of determining the structure of the Riemann surface associated with a Feynman integral is converted into an algebraic problem using the homological approach. This provides a systematic language for understanding the analytic properties of the general scattering amplitude. (J.F.P.)

## Particle Accelerators

*Refer also to abstracts 1556 and 2661.*

**2537** (AD-634717) A TEST OF THE ELECTRON PROPAGATOR BY MODIFICATION OF THE PRINCETON-STANFORD STORAGE RINGS. O'Neill, G. K. (Stanford Univ., Calif. High-Energy Physics Lab.). May 1966. Contracts Nonr-225(67); Nonr-1858(39). 44p. (HEPL-440). CFSTI $2.00 cy, $0.50 mn.

The Princeton-Stanford colliding-beam experiment has verified quantum electrodynamics up to 1.1 BeV/c as far as the photon propagator is concerned, and further runs at 550 MeV during 1966 will extend that limit a factor three in sensitivity. The question of modification of the rings for operation on positron-electron colliding beams at 550 MeV is discussed. It is pointed out that a conversion can be accomplished without major hardware changes, and that the resulting positron-electron storage ring could then be used for a very clean test of the electron propagator up to twice the invariant mass at which an apparent electrodynamic breakdown has been found at CEA. (auth)

**2538** (AECL-2613) BEAM EXCITATION OF RECTANGULAR AND SOC CAVITIES. Winterbon, K. B. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). June 1966. 50p. (FSD-ING-48). Dep. mn. AECL $1.50.

Bunches of charged particles passing through SOC accelerating cavities induce fields in the cavities, which alter the velocities of subsequent particles. These fields, and the resulting velocity and position changes, called deflections for short, are calculated for an idealized rectangular cavity. Then expectation values of the deflections for real SOC cavities are estimated. It was assumed that these fields can not be allowed to change the energies of the particles by more than 3% of the mean energy gain of the particles per transit through a cavity. On this basis it is estimated that the probability of a given cavity in the second or third stage SOC of the ING proposal being unsuitable is not greater than 2%. (auth)

**2539** (BNL-10650) EXPERIMENTAL RESULTS ON THE RCA 7835, AND INITIAL OPERATING PARAMETERS OF THE FTH 515. Keane, J. T.; McNerney, A. J. (Brookhaven National Lab., Upton, N. Y.). Sept. 29, 1966. Contract AT-30-2-GEN-16. 17p. (CONF-661021-13). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

Performance testing results of the RCA 7835 super power triode and the Thompson-Houston 515 Vapodyne triode, which is to be used as rf power sources for the proton liniac at BNL, are presented. (B.G.D.)

**2540** (BNL-10670) MEASUREMENTS AND CALCULATIONS ON THE 50-Mev BROOKHAVEN LINAC. Batchelor, K.; Chasman, R.; Werntz, T. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 18p. (CONF-661021-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Data are presented representing a series of measurements and calculations carried out on the 50-MeV Brookhaven linac. Many of the results obtained are applicable to the proposed AGS conversion program since the present cavity length is more than one and one half times greater than any cavity in the new proposal. Measurements of the transient and steady-state phase and amplitude changes between center and end of the center-fed cavity are presented with calculated values obtained from the theory of Nishikawa. Also beam energy measurements are presented together with some previous computational data. Good agreement is found between measurements and the computational data for phase and amplitude effects in the linac. (J.F.P.)

**2541** (BNL-10671) LINAC CAVITY FIELD CALCULATIONS. Dahl, P. F.; Jellett, K.; Parzen, G.; Giordano, S.; Hannwacker, J. P. (Brookhaven National Lab., Upton, N. Y.); Young, D. (Midwestern Universities Research Association, Stoughton, Wis.). [nd]. Contract AT(30-2)-Gen-16. 7p. (CONF-661021-4). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

The accuracy of mesh-relaxation computer programs for determining the resonant frequency and the electromagnetic fields of linac cavities is studied. An estimate of this accuracy is made by comparing the results of the computer programs JESSY and MESSYMESH with experimentally measured results. The percent difference between the measured and computed results are plotted. This difference varied from 0.13 to 0.95%. Qualitatively comparison with measured results indicated an error in the computer results for the frequency of about 0.5%. (J.F.P.)

**2542** (BNL-10687) LINACS OF THE FUTURE. Blewett, J. P. (Brookhaven National Lab., Upton, N. Y.). [nd]. Contract AT-30-2-GEN-16. 3p. (CONF-661021-12). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

Recent developments of the linac are reviewed, and specific plans for new injectors for large proton synchrotrons in increasing order of synchrotron energy are discussed. The future development of linacs is also considered. The major advance is thought to be cryogenic linacs, which except for rf structure, can yield continuous beams. A few speculative ideas are also mentioned. (J.F.P.)

**2543** (CERN-66-28) INDUCED $^{24}$Na ACTIVITY IN THE CONCRETE SHIELDING OF HIGH-ENERGY ACCELERATORS. Nachtigall, D.; Charalambus, S. (European Organization for Nuclear Research, Geneva (Switzerland)). Sept. 16, 1966. 68p. Dep. mn.

$^{24}$Na induced activity in the concrete shielding of high-energy accelerators is studied. It is found that besides $^{24}$Na produced by thermal neutron capture in $^{23}$Na, a significant amount of $^{24}$Na is produced by spallation processes from high-energy particles in other constituents of the concrete. By adding 0.3% boron to reduce the thermal neutron flux, the dose rate at the surface of CPS concrete due to $^{24}$Na is reduced only by a factor 3; this factor depends on the $^{23}$Na content of the concrete. Figures are presented which give the production of $^{24}$Na at different depths in the concrete and the attenuation length in the concrete for fast particles and thermal neutrons producing the $^{24}$Na. Production of other important induced radionuclides in high-energy accelerators is considered, and comparisons are made for the dose rates coming from $^{24}$Na and from these other radionuclides. (auth)

**2544** (LA-DC-8249) OPERATING CHARACTERISTICS OF A FULL POWER CLOVERLEAF ACCELERATOR TANK. Copenhagen, D. R.; Knapp, E. A.; Potter, J. M. (Los Alamos Scientific Lab., N. Mex.). Sept. 16, 1966. Contract W-7405-eng-36. 13p. (CONF-661021-3). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

An 805 MHz, forty-one cell cloverleaf accelerator tank was fabricated and evaluated. The operating parameters as well as the tuning procedures and problems associated with this particular model are discussed. Results from both low and high power tests are included. (auth)

**2545** (SLAC-PUB-208) KLYSTRONS FOR THE STANFORD LINEAR ACCELERATOR CENTER. Lebacqz, J. V.; Merdinian, G. K.; Bierce, R. W. (Stanford Linear Accelerator Center, Calif.). Aug. 1966. Contract AT(04-3)-400. 8p. (CONF-660932-1). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

From 6th International Conference on Microwave, Optical Generation, and Amplification, Cambridge, Mass.

A brief review is presented on the design and performance of the pulsed S-band klystrons for the Stanford Linear Accelerator. Included are the mean values of measured power output and an analysis of the information available to date on tube life. (B.G.D.)

**2546** (SLAC-PUB-221) SOME EFFECTS OF (NOT HAVING) COMPUTER CONTROL FOR THE STANFORD LINEAR ACCELERATOR. Mallory, K. B. (Stanford Linear Accelerator Center, Calif.). Oct. 1966. Contract AT(04-3)-400. 4p. (CONF-661021-16). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

Amongst the original guidelines for the design of the control system for the Stanford Linear Accelerator was suitability for ultimate computer control of the accelerator. Although computer control has not materialized, this design influence has produced unusual features in the system. Video information was to be digested at the source and spoon-fed to the computer: the present system for bringing video signals to the central control room is very sketchy. Large special-purpose data recording systems were considered noncompetitive with a small computer: there is now no automatic data-recording system. Subsystems which are basically nothing but local switch-gear were to be fully implemented outside of central control: Central Control is only incidentally con-

cerned with automatic phasing of the accelerator, personnel protection and beam shutoff interlock systems, and the automatic replacement of failed klystrons. (auth)

**2547** (SLAC-PUB-222) SLAC ALIGNMENT SYSTEM. Herrmannsfeldt, W. B. (Stanford Linear Accelerator Center, Calif.). Oct. 1966. Contract AT(04-3)-400. 17p. (CONF-661021-15). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

A review of the operating experiences with the laser alignment system of the two-mile linear accelerator is presented. It includes discussions of some of the special alignment techniques used prior to the initial start up of the accelerator. (auth)

**2548** (SLAC-PUB-223) MEASUREMENTS OF THE SLAC INJECTOR EMITTANCE. Miller, Roger H. (Stanford Linear Accelerator Center, Calif.). Oct. 1966. Contract AT(04-3)-400. 17p. (CONF-661021-17). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

The six-dimensional volume in phase space enclosing the beam from the SLAC injector was measured. The measurements reported for transverse and longitudinal phase volumes differ significantly from those used previously on the phototype injector. The method reported used a variable aperture plus glass plate (equivalent to a photographic film). The methods and results are compared for the prototype and final injectors. (B.G.D.)

**2549** (SLAC-PUB-224) BEAM BREAK-UP EXPERIMENTS AT SLAC. Altenmueller, O. H.; Farinholt, E. V.; Farkas, Z. D.; Herrmannsfeldt, W. B.; Hogg, H. A.; Koontz, R. F.; Kruse, C. J.; Loew, G. A.; Miller, R. H. (Stanford Linear Accelerator Center, Calif.). Oct. 1966. Contract AT(04-3)-515. 38p. (CONF-661021-14). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

A description of the beam break-up effect, both qualitatively and quantitatively, is presented as it has been observed and understood so far. Results derived from microwave cold tests, microwave beam tests, focusing beam tests, and a few other miscellaneous experiments involving the beam are discussed. From all these experiments, it is shown how the presently adopted corrective program evolved. A short description of the remedies is given, together with the improvements expected. (B.G.D.)

**2550** (SLAC-PUB-235) REPORT ON THE STANFORD LINEAR ACCELERATOR CENTER. Loew, G. A. (Stanford Linear Accelerator Center, Calif.). Oct. 1966. Contract AT(04-3)-515. 22p. (CONF-660918-8). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Instrumentation for High Energy Physics, Stanford, Calif.

A report is presented on the main features of SLAC, the main instrumentation along the accelerator and the beam switchyard and how they are tied together in two control rooms, and finally on the beam break-up phenomenon. (B.G.D.)

**2551** (UCRL-16830(Vol.1)) 200 Bev ACCELERATOR: STUDIES ON EXPERIMENTAL USE, 1964-1965. VOLUME I. PARTICLE PRODUCTION, EXPERIMENTS AND BEAMS. Chew, G. G.; Chinowsky, W.; Dutta, N.; (and others) (California Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1966. Contract W-7405-eng-48. 378p. Dep. mn. CFSTI $7.00 cy, $1.75 mn.

A collection of reports (UCID Series) is presented which is connected with the experimental use of the proposed 200 GeV accelerator. The reports are grouped in two broad categories: high-energy elementary particle reactions and experiments and secondary beams. (B.G.D.)

**2552** (UCRL-16830(Vol.2)) 200 Bev ACCELERATOR: STUDIES ON EXPERIMENTAL USE, 1964-1965. VOLUME II. EXPERIMENTAL EQUIPMENT, TARGETING, EXPERIMENTAL AREAS, AND FACILITIES. Chinowsky, W.; Dols, C.; Hughes, E.; (and others) (California Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1966. Contract W-7405-eng-48. 317p. Dep. mn. CFSTI $7.00 cy, $1.50 mn.

A collection of reports (UCID and UCRL Series) is presented which is connected mainly with the experimental use of the 200 GeV accelerator. The reports are grouped into two broad categories: experimental equipment and targeting, experimental areas, and facilities. (B.G.D.)

**2553** (UR-875-161) DESIGN STUDY FOR MUON AND ANTIPROTON FACILITY AT SLAC. Lobkowicz, F.; Green, D.; Serio, S. (Rochester Univ., N. Y. Dept. of Physics and Astronomy). Aug. 10, 1966. Contract AT(30-1)-875. 81p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The design feasibility of a storage ring at the SLAC facility is considered. This storage ring is for trapping antiprotons and mesons ($\mu$). A general description of the storage ring, its use as a meson ($\mu$) and antiproton facilities, and the reason for the selection of SLAC are discussed. It is believed that the feasibility of the project is definitely demonstrated and that the region of reasonable parameters is found. (J.F.P.)

**2554** USE OF LIE-SERIES METHODS FOR CALCULATING PARTICLE TRAJECTORIES IN ACCELERATOR SYSTEMS. Ehlotzky, F. (Univ., Innsbruck). Acta Phys. Austr., 23: 142-52(1966). (In German).

The essential formulas for the solution of differential equations by the Lie–Groebner method are given and the method is briefly explained. It is shown how this method can be used for the numerical treatment of differential equations of the isochronous AVF cyclotron, especially with respect to stability questions. (J.S.R.)

**2555** EQUIPMENT FOR TEST OF HEAVY ION SOURCE. Kohno, Isao; Tonuma, Tadao (Inst. of Physical and Chemical Research, Tokyo). Rika Gaku Kenkyusho Hokoku, 41: 251-8 (Nov. 1965). (In Japanese).

A description is given of the design and performance of the heavy-ion source test equipment, which was constructed for the research and development of heavy-ion sources for use in the 160-cm cyclotron (of the Institute of Physical and Chemical Research). Then, the behaviors of the ion sources, tested with this equipment, of the hot cathode, indirectly heated cathode, and PIG types are described, as well as the relative intensities of $N^+$, $N^{2+}$ and $N^{3+}$ ions produced by the hot cathode-type ion source. The test equipment was shown capable of testing heavy-ion sources. (NSA of Japan)

**2556** INVESTIGATION OF A HIGH-INTENSITY RADIOFREQUENCY ION SOURCE. Roosz, Jozsef; Gombos, Peter; Valyi, Laszlo. Magyar Tud. Akad. Kozp. Fiz. Kut. Int. Kozlem., 14: 333-41(1966). (In Hungarian).

The development of a high intensity radiofrequency ion source with a positive hydrogen ion yield is described. The source can be continuously operated and has a long lifetime. Investigation of its operational characteristics shows the optimum obtainable hydrogen ion current to be of 10 mamp intensity for 30 $cm^3/h$ gas consumption at atmospheric pressure, 140 W radiofrequency output and 8 kv extracting voltage. (auth)

**2557** SYNCHRONIZATION OF STARTUP PULSES WITH ASSIGNED HIGH-VOLTAGE PHASE. Egorov, A. A.; Samokhin, I. A.; Panasyuk, V. S.; Yudin, L. I. (Inst. of Nuclear Physics, Novosibirsk, USSR). Prib. Tekh. Eksp., No. 3, 98-101(May-June 1966). (In Russian).

The apparatus, designed for the synchronization of startup pulses with assigned phase of sinusoidal high-frequency voltage with a precision of ~1 nsec, was described. By means of special strobe pulses, the output pulse of the installation can be combined with any part of the sinusoidal hf voltage, pulsed or continuous, at frequencies up to 100 MHz. The apparatus can be used in different systems for the registration of particles, in electronic layouts of accelerators, and in oscillographs for visual observation of separate sections of the hf voltage curve. (tr-auth)

**2558** CONTROL OF 680-Mev SYNCHROCYCLOTRON. Danilov, V. I.; Enchevich, I. B.; Rozanov, E. I.; Tomilina, T. N.; Shestov, A. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Prob. Tekh. Eksp., No. 3, 19-22(May-June 1966). (In Russian).

The control methods for the different operational modes of the synchrocyclotron are described. The control system guarantees different operational modes of the accelerator and synchronizes them with the experimental installations. Pulse phototransmitters are used for synchronization and their following frequency agrees with the modulation frequency of the generator. The binding precision (0.12%) determines the mechanical precision of the execution of the variator blade. The control system is distinguished from the first by its very high reliability. Lost time because of shutdown does not exceed 0.1% of the operational time of the accelerator. (tr-auth)

**2559** MODULATION OF HIGH-FREQUENCY VOLTAGE PULSE AT SYNCHROTRON RESONATOR. Geltsel, M. Yu.; Ostreiko, G. N.; Ponasyuk, V. S.; Yudin, L. I. (Inst. of Nuclear Physics, Novosibirsk, USSR). Prib. Tekh. Eksp., No. 3, 23-4 (May-June 1966). (In Russian).

The installation used for the variation, according to given rules, of the form of the front of the strong $\pi$-shaped modulating pulses on the anode of the tube of the high-frequency amplifier was described. The anode modulator of this type gives the possibility by a simple method of modulating the high-frequency voltage to the accelerating resonator of the synchrotron for obtaining the optimum conditions for trapping particles during acceleration. The installation can be altered to other analogous cases. (tr-auth)

**2560** MECHANISM OF ELECTRON CAPTURE IN A BETATRON. Lobanov, Yu. N.; Ekivin, V. V. (Moscow State Univ.). Prob. Tekh. Eksp., No. 3, 25-7(May-June 1966). (In Russian).

Experimental results, obtained on the betatron at energies of

35 MeV, on the study of the effects on electron capture of a metallic screen, movable radially from the interior and exterior walls of the accelerator chamber were reported. Some deductions were made on the character of the mechanism of the electron operation of the accelerator. (tr-auth)

**2561** STARTUP OF NEW ACCELERATOR: SYMMETRIC RING PHASOTRON OF THE LEBEDEV INSTITUTE OF PHYSICS AT THE USSR ACADEMY OF SCIENCES. Kolomenskii, A. A.; Kanunnikov, V. N.; Kazanskii, L. N.; Ovchinnikov, E. P.; Papadichev, V. A.; Semenov, S. S.; Fateev, A. P.; Yablokov, B. N. At. Energ. (USSR), 20: 513-14(June 1966). (In Russian).

The concept of the new electron accelerator, designated as the KF machine which was started up recently, was proposed nine years ago. In this constant magnetic field accelerator with strong focusing, the increase of the magnetic field with time was replaced by a radial increase of the field, corresponding to the growth of energy of the particles. The machine was designed to obtain high-intensity particle beams, allowing simultaneous acceleration of two colliding beams which rotate in opposite directions. It will be used, among other applications, for studying problems related to the stability of rotating particle beams. The magnet consists of 40 geometrically identical blocks with alternating poles; the absolute field increases exponentially with the radius according to $r^n$, from 27 oersted at r = 117 cm to 4.2 Koersted at r = 160 cm. The exceptionally high value of n = 16 results in a steep increase of the field. The electrons are injected at energies ranging from 80 to 85 keV and are ultimately accelerated up to energies of 25 to 30 MeV. Particle losses during phasotron-type operation, including passage through the critical energy range, were found to be relatively low. (TTT)

**2562** START-UP OF KASAKHSTAN CYCLOTRON. Nemenov, L. M.; Anisimov, O. K.; Arzumanov, A. A.; (and others). Izv. Akad. Nauk Kaz. SSR, Ser. Fiz.-Mat. Nauk, No. 2, 3-15(Apr.-June 1966). (In Russian).

The design and startup data are given for the U-150 cyclotron having an electromagnet pole diameter of 150 cm. (R.V.J.)

**2563** INVESTIGATION OF A RADIOFREQUENCY NEGATIVE HYDROGEN ION SOURCE. Gombos, Peter; Roosz, Jozsef; Valyi, Laszlo. Magyar Tud. Akad. Kozp. Fiz. Kut. Int. Kozlem., 14: 325-31(1966). (In Hungarian).

Investigations of a radiofrequency negative ion source are described. The exchange is performed by $H_2$ gas target formed in the extracting electrode with a long extraction channel. The $H^-$ beam extracted from the source emerges with 18 keV energy, 9 μamp intensity, the width of the energy spectrum being 300 eV, its angular scattering 11 mrad for gas consumption of 20 cm/h. The lifetime of the ion source exceeds 500 hours. (auth)

**2564** LINEAR THEORY OF THE EXTERNAL INJECTION IN THE CYCLOTRON WITH SECTIONED MAGNETIC SYSTEM. Lembra, Yu. Izv. Akad. Nauk Est. SSR, Ser. Fiz. Mat. Tekh. Nauk, 15: 329-33(1966). (In Russian).

A method of particles drifting along a straight line which separates two regions with different values of a homogeneous magnetic field was proposed by Gladyshev et al. for injecting particles into the cyclotron with sectioned magnetic system. A modulus of Floquet's function for the equation of vertical oscillations in the case of above mentioned drifting is calculated. It is shown that the modulus of Floquet's function and, consequently, the amplitude of vertical oscillations, has maximums at the points of the boundary line and minimums at the middle points of the trajectory in respective regions. (auth)

**2565** DEVELOPMENT OF HIGH-ENERGY ACCELERATORS. Livingston, M. Stanley (ed.). Classics of Science Series. Volume III. New York, Dover Publications, Inc., 1966. 328p. $2.50.

The origins of the important principles and concepts which have proven successful in the field of accelerator development are described. These are direct voltage acceleration, resonance acceleration, synchronous acceleration, alternating gradient focusing. (J.F.P.)

**2566** EXTERNAL BEAM-PULSER FOR USE WITH ACCELERATORS. Sherwood, Jesse E. 5p. (CONF-651135–7). ORAU. Gmelin, AED-CONF-65-402-18.

From American Physical Society, Southeastern Section, Charlottesville, Va.

A description is given of a post-accelerator pulser that was built and installed on a 2-MeV Van de Graaff at Redstone Arsenal. A useful feature of the design is the possibility of locating the rf generator remotely from the accelerator. (L.B.S.)

**2567** DETECTOR FOR A CHARGED-PARTICLE BEAM. Komai, Kenichiro (to Hitachi Ltd.). Japanese Patent 1965-20640. Sept. 14, 1965. Filed Mar. 16, 1964.

An improved beam detector is proposed which is located in the beam duct of a charged-particle accelerator. It consists of a cylindrical tube electrode with two air-tight electric-insulators (flanges) at both ends of the tube, and an outer shielding tube separated from the electrode tube with a specified air-gap. The cylindrical tube electrode is installed between an accelerator tube and a target compartment by means of the flanges. The advantages obtained are that it is conveniently possible to remove the elements of a detector from the path of charged particles, and it is not necessary to use electrical terminals with highly air-tight electrical-insulation in the conventional beam detector. (NSA of Japan)

**2568** TETRODE-MAGNETS DEVICE FOR FOCUSING CHARGED PARTICLES. Kuroda, Kunishige; Kimura, Hiroshi (to Hitachi Ltd.). Japanese Patent 1965-25997. Nov. 11, 1965. Filed May 20, 1964.

An improved device for focusing charged-particles, consisting of two tetrode magnets, is proposed. By using at least one tetrode permanent magnet, the exciting power source and coils for this magnet can be eliminated, thereby simplifying the overall construction, reducing the building cost, and making it easy to operate the device. The members of each tetrode magnet are arranged as follows: the two N poles and S poles are arranged alternately, surrounding the path of a charged particle beam to be focused, such that the poles of the same polarity are opposed to each other; then the top faces of the two (opposing) magnetic poles form a part of the rectangular hyperbola. Two such tetrode magnets are installed along the path of the charged-particle beam for the purpose of focusing. One at least of the tetrode magnets is of a permanent magnet. (NSA of Japan)

**2569** COCKCROFT-WALTON'S PARTICLE ACCELERATOR. Suematsu, Shigeru; Suganomata, Shinji (to Hitachi Ltd.). Japanese Patent 1965-25998. Nov. 11, 1965. Filed July 14, 1964.

In the Cockcroft-Walton's particle accelerator proposed, the output of a beam current, and of the high-voltage producing device can be adjusted independently from each other. It consists of a particle source, an accelerating tube to accelerate the particles from the source, and a high-voltage producing device for the particle acceleration. In the high-voltage producing device, on the earthing side a main condenser and its auxiliary are connected cumulatively and other similar ones are also connected differentially; these two pairs are connected in series. On the high-potential side, two condensers are connected differentially. The two sides, viz., earth and high-potential, connect to each other by two rows of rising condensers; and the middle point of the earth-side series of main and auxiliary condensers, and that of the high-potential side series of two condensers are connected by a row of smoothing condensers. (NSA of Japan)

**2570** ELECTRON-INJECTING DEVICE FOR A BETATRON. Masuda, Masami; Suematsu, Shigeru (to Hitachi Ltd.). Japanese Patent 1965-26000. Nov. 11, 1965. Filed Sept. 9, 1964.

An improved electron-injecting device is proposed which is capable of raising the betatron output to the maximum value by a simple manipulation. By the method proposed, the pulses can easily be adjusted to the optimum times, thereby permitting the betatron to operate at its maximum output. Two peakers are provided, and the injection pulse and the contraction pulse from the respective peakers are applied to the electron gun at the optimum time difference. Only by adjustment of the times can the maximum output be attained. A pulse-shaping circuit and multiplying circuit are connected to a peaking transformer, which is excited by the magnetic fluxes produced in the magnetic poles; and two of this series are provided. The outputs of the two peaking transformers are thus converted into the respective pulse signals; one is applied to an electron gun, and the other to the contraction circuit. In these injection and contraction peakers, ion cores whose saturated magnetic-flux densities are the same but saturation characteristics are different from each other, are used in the respective peaking transformers; a vias-power source is used in common by the two peaking transformers. Thus, a given time lag can be had between the two pulses from the (said) two different peakers. (NSA of Japan)

**2571** ACCELERATING TUBE. Okada, Tsutomu; Oshima, Kotaro (to Tokyo Shibaura Electric Co., Ltd.). Japanese Patent 1965-26520. Nov. 17, 1965. Filed June 17, 1963.

In the conventional accelerating tubes, two types of accelerating-tube cooling systems are used. In one, a cylindrical body with a slightly larger inner diameter than the outside diameter of an accelerating tube is installed concentrically with the latter, and cooling water is flown through the space between the two cylindrical bodies. In the other type, steel tubular lines are welded onto the outer surface of an accelerating tube, and coolant water flows through the lines. The former type has the drawbacks of complicated structure and large amounts of coolant water required. The

latter, on the other hand, has the disadvantage of the distortion of an accelerating tube, due to the localized heating from the welding, resulting in a difficulty in supporting the accelerating tube. In the accelerating tube proposed, these drawbacks are eliminated, with the time required for constructing an accelerating tube being reduced considerably, its support easy and only a small amount of cooling water required. Through the wall of the accelerating tube (proposed), which is essentially made up of the short cylindrical bodies, penetrate holes in the axial direction for passage of coolant water. (NSA of Japan)

**2572** ACCELERATING TUBE FOR A LINEAR ELECTRON-ACCELERATOR. Saito, Tatsuo (to Hitachi Ltd.). Japanese Patent 1965-27279. Nov. 30, 1965. Filed Dec. 19, 1964.

By the method proposed, an accelerating tube with high air tightness can be constructed easily and very precisely. A short cylindrical body and a disc with a central hole for passage of electrons are fabricated in one entity, that is to say two members are not connected together. A plurality of these entities are arranged end to end to form an accelerating tube, and at both ends of this accelerating tube, a flange is provided to make the accelerating tube and the outer tube in one body; between the flange and the end face of the outer tube is a material for air-tightness purposes. (auth)

**2573** CHARGED-PARTICLE SOURCE EQUIPMENT. Kondo, Toshiro (to Hitachi Ltd.). Japanese Patent 1965-26800. Nov. 22, 1965. Filed Dec. 27, 1963.

An improvement is made for charged-particle source equipment (proposed), especially in the protective circuits for a thermoelectron-emitting filament. The current emitted from an electron gun is usually controlled stably by changing appropriately the heating current to the filament. In the charged-particle source equipment are included the following: a thermoelectron-emitting device, consisting of a filament emitting thermoelectrons, and a dc source for supplying heating current to the filament; a transistor between the "emitter" and collector, for controlling the filament-heating current, which is connected in series to the filament and to its dc source; circuits for detecting the variation in the thermoelectron current from the electron gun; a device, which changes the filament-heating current so as to stabilize the emitted thermoelectron current, by changing the base voltage of the said transistor in accordance with the (said) variation in the thermoelectron current; a resistor located between the "emitter" of the (said) transistor and the filament; a device for limiting the filament-heating dc current—consisting of a silicon diode, located between the filament side of the said resistor and the base of the former transistor, through which a current flows when the filament heating dc current exceeds a predetermined value; and a device for indicating that a current is flowing through the silicon diode. (auth)

**2574** CHARGED PARTICLE-RAY DEVICE. Munakata, Tadasuke; Katagiri, Shinjiro (to Hitachi Ltd.). Japanese Patent 1965-22518. Oct. 5, 1965. Filed Nov. 27, 1963.

A device is proposed for obtaining a charged-particle beam of constant intensity and beamspot even when an alternating current is used for heating the filament. It consists of the following: a charged-particle source; an accelerator for the charged-particle beam from its source; a focussing device for the beam and its ac source; an ac source for heating the filament to emit charged particles; a circuit for making the phase difference between the two ac sources 90°; and a mechanical iris diaphragm for the charged-particle beam, located above the specimen surface. (NSA of Japan)

**2575** SECTOR-FOCUSED CYCLOTRON. Steimel, Karl (to Licentia Patent-Verwaltungs-GmbH). German Patent 1,223,968. Sept. 1, 1966. Filed Nov. 19, 1964.

In order to eliminate disturbances of the magnetic sector field caused by the magnetically effective elements of the extraction system addition, similar magnetic elements are situated as phantoms in all of the sectors. (Gemlin Inst.)

**2576** DEVICE FOR MEASURING THE POSITION OF AN ACCELERATED-PARTICLE BEAM IN PARTICLE ACCELERATORS. Seki, Yoshinaga (to Mitsubishi Electric Mfg. Co., Ltd.). Japanese Patent 1965-20840. Sept. 15, 1965. Filed June 23, 1961.

An improved device is proposed for measuring the position of an accelerated-particle beam. For detection of the beam characteristic of accelerated particles such as electrons, it is necessary to have slit movement in the X and Y directions and to read the respective positions. In the device proposed previous unnecessary positions in the corners of the X and Y axes are removed and a shielding disk, with a simple slit, capable of easy movement by revolution on the concentric circles, is employed. Thus, by passing the beam at a particular position, through the small slit, and by combining with a beam detector such as a Faraday cup, it is easily possible to detect the intensity characteristic of an accelerated-particle beam. In this case, the slit with the shielding plate is moved by combining the two movements, namely, in the X and Y directions and the revolving movement on the concentric circles, and the degree of the beam concentration and the deviation from the center line are read. It includes the two different movement mechanisms for the shielding disc with a slit; one is for its linear movements and the other for the movement by revolution on a given center. The position of passage of an accelerated particle beam is measured by moving the (said) shielding plate. (NSA of Japan)

**2577** BETATRON AND SIMILAR ACCELERATORS. Iwashita, Fumio (to Tokyo Shibaura Electric Co., Ltd.). Japanese Patent 1965-20839. Sept. 15, 1965. Filed Oct. 7, 1964.

In the betatron and similar accelerators proposed, the voltage applied for the electrons to enter the accelerating tube (or the cathode), and the electron-injection time, corresponding to the applied voltage, can be automatically known very accurately. In addition, when this voltage is changed, the electron injection can be changed accordingly. In this way, the electron-injection time, optimum to the applied voltage, can be detected easily. Thus, the electrons can be placed, in the most favorable condition, in the accelerating stable orbit of the accelerating tube. It consists of the following: the electromagnets for accelerating the electrons; the coils energizing these electromagnets; the accelerating tube, placed in the magnetic field produced by means of the (said) coils; a pickup coil for taking out the standard pulses from this accelerating tube; a circuit, which delays these standard pulses until the electron-injection time corresponding to the applied voltage between the cathode and anode; the first pulse-shaping circuit, energized by this delay circuit; the voltage regulator, connected to a power source; the second pulse-shaping circuit, connected to the output side of the voltage regulator and having a condenser; a device, operated by means of the output pulses of the first pulse-shaping circuit which produces the control pulses applied between the (said) cathode and anode by discharging the (said) condenser; the first voltage-selecting circuit, connected to the (said) delay circuit, which produces a voltage analogous to the voltage, delaying the injection time (this latter voltage, which gives the optimum electron injection time corresponding to the injection voltage, is previously determined); and the second voltage-selecting circuit, which adjusts the rated output voltage of the first voltage-selecting circuit to the output voltage of the (said) control pulse-producing device. (NSA of Japan)

**2578** SCANNING DEVICE FOR A CHARGED-PARTICLE BEAM. Komai, Kenichiro (to Hitachi Ltd.). Japanese Patent 1965-20639. Sept. 14, 1965. Filed Jan. 13, 1964.

An improved electric circuit is proposed for scanning the energy distribution of a charged particle beam. The conventional electric circuit, employing a relatively expensive triangle-wave generator and a dc supply for energizing the scanning coil, is considerably simplified by replacing the triangle-wave generator by a pole-exchangeable time switch and a scanning coil with a relatively long time constant enough to flow a linear decreasing electric current. (NSA of Japan)

**2579** LINEAR ACCELERATOR FOR CHARGED PARTICLES. Komai, Kenichiro (to Hitachi Ltd.). Japanese Patent 1965-20637. Sept. 14, 1965. Filed Mar. 23, 1964.

The invention relates to the construction of a low-power hf linear accelerator which can accelerate effectively the phase-collected particles (e.g., electrons) by a velocity-modulation phase-collector. It consists of a short accelerator tube and its configuration between a source of charged particles and a light-velocity accelerating tube with a hf oscillator. The length of the accelerator tube is less than twice the wavelength of the hf signal and the accelerator tube is arranged to satisfy the following relation:

$$\frac{\alpha}{2\pi} = \frac{1 - \frac{\beta e_0}{\beta W_0}}{\sqrt{1 - \left(\frac{\beta e_0}{\beta W_0}\right)^2}}, \quad \beta W_0 < 1$$

where $\alpha$ is the normalized intensity of the electric field at the entrance of the accelerator tube, $\beta W_0$ is the phase velocity of the hf signal, and $\beta e_0$ is the incident velocity of charged particle. (NSA of Japan)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstracts 2028, 2029, 2705, and 2722.*

**2580** (AECL-2600) THE AECL STUDY FOR AN INTENSE NEUTRON-GENERATOR (TECHNICAL DETAILS). Bartholomew, G. A.; Tunnicliffe, P. R. (eds.) (Atomic Energy of Canada Ltd., Chalk River (Ontario)). July 1966. 672p. Dep. mn. AECL $10.00.

The scientific and technical details of the conceptual design of the AECL intense neutron generator (ING) are presented. Some of the systems described are a three-stage separated-orbit cyclotron delivering 65 mA of 1-BeV protons in continuous operation; target areas and associated experimental facilities; beam transport systems; support and shelter structures; radiation shielding; main control center; offices and laboratory building; and utilities and auxiliary service systems. Also included are figures on construction costs and operating costs. (S.F.L.)

**2581** (GA-5319) EXPERIMENTAL AND THEORETICAL NEUTRON SPECTRA. Young, J. C.; Huffman, D. (comps.) (General Dynamics Corp., San Diego, Calif. General Atomic Div.). May 22, 1964. Contract AT(04-3)-167. 370p. Dep. mn. CFSTI $7.00 cy, $1.75 mn.

Experimental and theoretical neutron spectra are given for the following moderators with various poisons at different temperatures and in several geometries: Be, BeO, C, $CH_2$, $C_6H_6$, $D_2O$, LiH, and ZrH. The compilation is designed to enable reactor designers to make comparative calculations to check their numerical procedures and basic physics data. (S.F.L.)

**2582** (IN-1021) NEUTRON RESONANCE ABSORPTION. Scheffler, W. A. (Idaho Nuclear Corp., Idaho Falls). Sept. 1966. Contract AT(10-1)-1230. 25p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

An investigation of the solution to the slowing-down equations for a homogeneous mixture of substances is presented. The slowing-down equation can be reduced to a system of first-order differential equations under rather mild assumptions. The assumptions do not limit the physical phenomena associated with resonance absorption. Flux oscillations and resonance shadowing are taken into account by the form of the solution. Furthermore, the solution is amenable to numerical calculation and has the same form as the exact solution for hydrogen. (auth)

**2583** (NAA-SR-Memo-11686) SIZDEK II: A PROGRAM TO CONSTRUCT MULTIGROUP CROSS-SECTION LIBRARIES. Vernon, A. R. (Atomics International, Canoga Park, Calif.). Jan. 19, 1966. Contract AT(11-1)-Gen-8. 22p. Dep. mn. CFSTI $1.00 cy, $0.50 Mn.

SIZDEK II is a program to construct punched-card cross-section libraries for SIZZLE, AIM-6, BIP, ELMOE, or DTF. Input is most convenient if all or most of the data is available in a FAIM or CAESAR II binary library, but the number of changes allowed is unlimited. Output libraries are limited to a maximum of 18 energy groups and five downscatter groups. An option is also provided to omit the punched-card output and list all or part of a FAIM or CAESAR II library. (auth)

**2584** (NAA-SR-Memo-11907) AN UPDATED SIXTEEN-GROUP HANSEN-ROACH STRUCTURE LIBRARY. Ottewitte, E. H. (Atomics International, Canoga Park, Calif.). May 12, 1966. Contract AT(11-1)-Gen-8. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The contents of a library of revised Hansen-Roach 16-group cross sections are summarized and are discussed. Modified Be and Zr cross sections are included together with $^{239}Pu$ cross sections and cross sections of other elements used in SNAP reactors. (D.C.W.)

**2585** (SC-DC-66-1502) THERMAL NEUTRON FLUX PERTURBATIONS INDUCED BY ACTIVATING FOILS IN MAXWELLIAN FLUXES IN WATER. Walker, J. V.; Koelling, J. (Sandia Corp., Albuquerque, N. Mex.). July 1966. Contract AT(29-1)-789. 17p. (CONF-660911-1). Dep. mn. CFSTI $1.00 cy, $0.40 mn.

From Conference on Radiation Measurements in Nuclear Power, Berkeley, England.

The modified one-speed Skyrme theory for neutron flux perturbations by Ritchie and Eldridge has been extended for use in Maxwellian neutron distributions in water. The energy dependence of the one-speed g-factor has been assumed from the measured energy dependence of the neutron transport properties in water, and subsequent integrations have produced an average value for each term of the one-speed theory. The energy dependence of the neutron diffusion length and transport mean free path was determined from the work of Reir and DeJuren and the dependence of the absorption probability was represented by a form suggested by Tittle. An average g-factor is defined and compared to the one-speed Ritchie and Eldridge g-factor evaluated with spectral averaged parameters. Likewise the missing neutron reaction rate, the product of the absorption probability times the g-factor, computed from the averaging process and from the one-speed approximation for the g-factor are compared. It is observed that this reaction rate for water, based upon the averaging process, is approximately 25 percent greater than with the one-speed approximation. Experimental activation perturbations are reported for indium foils in pure and borated water. It is observed that excellent agreement is obtained between the measured perturbations and those computed from the Maxwellian averaged theory. (auth)

**2586** (NP-tr-1417) MEASUREMENT OF COHERENT SCATTERING OF NEUTRONS BY MOLTEN SODIUM, CESIUM AND BISMUTH AT VARIOUS TEMPERATURES. Oehme, H.; Richter, H. Translated by M. C. Wilson (Atomic Energy Research Establishment, Harwell, Eng.), from Naturwissenschaften, 53: 16(1966). 4p. Dep. mn. JCL $1.10 fs, $0.80 mf.

Neutron-beam diffraction experiments were carried out on molten Na at 110, 300, and 525°C, on Cs at 48 and 290°C, and on Bi at 325 and 725°C. Curves of scattered beam intensity vs $\sin\Theta/\lambda$ are given for sodium and cesium at various temperatures. (S.F.L.)

**2587** COMPARISON OF NONSTATIONARY METHODS FOR THE DETERMINATION OF DIFFUSION PARAMETERS. Fleck, C. M.; Kopitsch, F. (Oesterreichische Hochschule, Vienna). Acta Phys. Austr., 23: 350-7(1966). (In German).

Three nonstationary methods are shown for the determination of the diffusion parameters of thermal neutrons. These methods use a time-varying source of thermal neutrons and are compared with the usual methods of fast pulsed neutron sources and stationary poisoning experiments. The three methods are characterized by the time behavior of the thermal source thickness as a sinusoidal source, a $\delta$-shaped source, and an exponential source. The results obtained with a $\delta$ source on the neutron-diffusion parameters of water are tabulated and compared with the results of other authors. (J.S.R.)

**2588** CALCULATION OF THE Cd CORRECTION FACTOR FOR AN EXACT DETERMINATION OF NEUTRON TEMPERATURE BY THE TRANSMISSION METHOD. Fleck, C. M.; Steuer, M. (Oesterreichische Hochschule, Vienna). Acta Phys. Austr., 23: 358-63(1966). (In German).

In the determination of the neutron temperature in mixed neutron fields it is necessary to measure the thermal transmission with a Cd difference measurement. If a detector is used whose cross section has a 1/v pattern in the epithermal range, a calculation of $F^{\ell}_{Cd}$ and $F^{\pm}_{Cd}$, the Cd correction factors of the detector foil, is possible for a thick 1/v absorber. The use of the joining function makes it possible to obtain a reliable value for $F^{\pm}_{Cd}$. (tr-auth)

**2589** SINGULAR EIGENFUNCTION EXPANSION IN ANISOTROPIC TRANSPORT THEORY. Sattinger, D. H. (Univ. of California, Los Angeles). J. Math. Anal. Appl., 15: 497-511(Sept. 1966).

Let K be a compact symmetric integral operator on $L_2(-1,1)$ with kernel $k(u,u')$ which is real and analytic on $-1 \leq u,u' \leq 1$. The eigenvalue problem $(s-u)g_s(u) = sKg_s = s\int_{-1}^{1} k(u,u')g_s(u')du'$, where s is a complex number. It is shown that if $f(\mu)$ is Hölder continuous on $-1 < u < 1$, then f can be expanded in the eigenfunctions of the problem provided that one admits generalized functions (distributions) as singular eigenfunctions corresponding to the continuous spectrum $-1 < s < 1$. (D.C.W.)

**2590** ENERGY-DEPENDENT NEUTRON TRANSPORT THEORY IN PLANE GEOMETRY. II. EIGENFUNCTIONS AND FULL-RANGE COMPLETENESS. Leonard, A.; Ferziger, Joel H. Nucl. Sci. Eng., 26: 170-80(1966).

An earlier treatment of the energy-dependent transport equation is extended to include the case in which cross sections are functions of energy. The technique again consists of finding solutions to the homogeneous transport equation after expansion in terms of a complete set of functions in the energy variable. Unlike the problem treated earlier, the full-range completeness theorem for these eigenfunctions requires the solution of a coupled set of singular integral equations. This solution is effected by a generalization of a trick used by Case and is applied to the problem for the infinite-medium Green's function. Numerical results are given for a heavy gas model. (auth)

**2591** ENERGY-DEPENDENT NEUTRON TRANSPORT THEORY IN PLANE GEOMETRY. III. HALF-RANGE COMPLETENESS AND HALF-SPACE PROBLEMS. Leonard, A.; Ferziger, Joel H. Nucl. Sci. Eng., 26: 181-91(1966).

A set of elementary solutions to the energy-dependent Boltzmann equation, which was derived in the preceding paper, is shown to possess a half-range completeness property that allows the exact solution to energy-dependent half-space problems and the reduction of finite-slab problems to rapidly convergent Fredholm equations. Results follow an analogy with Case's work on the one-velocity transport equation, except that a system of singular integral equations is encountered, which gives rise to the Hilbert problem for matrices. It is shown that the methods of Muskhelishvili and Vekua are applicable to this matrix problem and lead to the consideration of a class of Fredholm equations to obtain the solution. The explicit form of the Fredholm equation for the present problem is derived by extending the analysis of the scalar Hilbert problem to the matrix case. Applications of the completeness proof are made to the albedo and Milne problems for a half space. (auth)

**2592** NEW APPROACH TO HALF-SPACE TRANSPORT PROBLEMS. Pahor, S. Nucl. Sci. Eng., 26: 192-7(1966).

The solutions of various time-independent one-speed half-space transport problems, such as the generalized Milne and albedo problems, are derived using the Chandrasekhar S-function and the Case eigenfunctions. First, the S-function is expressed by Chandrasekhar's H-function and Busbridge's q-polynomials. These polynomials can be separately determined by solving systems of linear equations. Using the S-function, the emerging distribution is obtained by simple physical arguments. Then, the distribution inside the medium is found by applying full-range orthogonality relations between the Case eigenfunctions. (auth)

**2593** GAUSSIAN APPROXIMATION FOR THE DESCRIPTION OF SCATTERING OF SLOW NEUTRONS BY MOLECULES. Kovalchuk, V. G. Ukr. Fiz. Zh., 11: 900-2(1966). (In Ukrainian).

An attempt was made to determine the accuracy of the Gaussian approximation for describing slow neutron scattering by molecules. To establish the applicability of the Gaussian expression, correlations were made between the precise moment of the neutron scattering curve and the moment in Gaussian approximation. (R.V.J.)

**2594** CALCULATION OF THE FUNDAMENTAL TIME-EIGENVALUE OF THE SPACE-ENERGY DEPENDENT TRANSPORT EQUATION IN A SPHERE. Gotusso, Laura (Politecnico, Milan); Montagnini, Bruno; Pierpaoli, Valeria. Nukleonik, 8: 341-7(Aug. 1966).

The eigenvalue integrodifferential Boltzmann equation is converted into the integral form, in which the eigenvalue $\lambda$ is considered as a parameter. The integral equation is solved for each $\lambda$ by means of the Feynman technique and its maximum eigenvalue $\chi_1(\lambda)$ is determined. The value of $\lambda$ for which $\chi_1(\lambda) = 1$ corresponds to the fundamental time-eigenvalue of the Boltzmann equation. Calculations are presented for a homogeneous sphere and the free gas scattering kernel. It is shown that $\chi_1(\lambda) < 1$ for any permissible $\lambda$, if the radius of the sphere is very small, so that no discrete eigenvalue exists. This confirms the results of previous theoretical work. The Feynman approximate solution is compared with the exact solution of the integral transport equation in the case of a simple degenerate scattering kernel, and is always found to be very accurate. (auth)

**2595** MODULATION OF DIFFRACTED NEUTRONS WITH A PIEZOELECTRIC CRYSTAL. Parkinson, T. F.; Moyer, M. W. (Univ. of Florida, Gainesville). Nature, 211: 400-1(July 23, 1966).

A quartz piezoelectric crystal with a resonant frequency of 500 kC/sec was used to modulate a diffracted beam of reactor neutrons. It was found that a sine-modulated beam could be obtained with the oscillating crystal. (S.F.L.)

**2596** TIME EIGENVALUES AND DEGENERATE KERNELS IN NEUTRON THERMALIZATION. Shapiro, Charles S. Syracuse, N. Y., Syracuse Univ., 1965. 111p.

Thesis.

A theoretical analysis of the pulsed neutron experiment is presented. This analysis leads to the "time eigenvalue problem" which is solved to determine the discrete spectrum of eigenvalues and the associated eigenfunctions of the neutron distribution. The solution is obtained for some physical models by six different methods, four of which involve a new method of replacing the scattering kernel by a synthetic, degenerate kernel which reproduces important properties of the true kernel. The solutions obtained with this degenerate kernel method are compared with that obtained by the well known polynomial method, for which both energy and velocity polynomials have been used. The physical models studied include the heavy crystal model using both the Debye and the Einstein distributions for the frequency distribution of the normal modes, and for values of the Debye (Einstein) temperature ranging from zero to $\theta/T(\omega_E/T) = 10.0$; the free gas-model for values of the mass ratio from zero to infinity; and a model for water due to Nelkin. The results indicate that the minimum value of $\nu\Sigma_s(v)$ significantly affects the structure of the time eigenvalue spectrum and plays a central role in the time evolution of a neutron pulse. The significance of this to the pulsed neutron experiment is discussed along with a comparison of the results with experiments. The merits of the degenerate kernel method is demonstrated as well as the improved convergence obtained by using a velocity formulation as opposed to an energy one. Finally, the inadequacy of some popular approximations used in the past is demonstrated. Solutions of the "space eigenvalue problem" for the heavy crystal model are presented. (Dissertation Abstr.)

**2597** EPITHERMAL NEUTRON INELASTIC SCATTERING BY ROOM TEMPERATURE WATER AND POLYETHYLENE. Kirouac, George J. Troy, N. Y., Rensselaer Polytechnic Inst., 1965. 228p.

Thesis.

The neutron inelastic scattering properties of polyethylene and water were investigated at room temperature within the incident neutron energy range of 0.1 ev to 1.8 ev. Measurements of the energy distribution of inelastically scattered neutrons were made at three laboratory angles: 25, 60 and 90°. A high-intensity neutron source is provided by the interaction of a linear electron accelerator beam with a high Z target material. The incident and scattered neutron velocity is measured by a time-of-flight technique which requires phasing the pulsing of the linear accelerator with the rotation of a 14,400 rpm neutron chopper. Neutron background was minimized by incorporating extensive shielding between the source and the final neutron detectors. The time-of-flight distribution of the scattered neutrons was converted to the double differential inelastic scattering cross section, $\partial^2\sigma/\partial\Omega\partial E$, for nine separate incident neutron energies for both materials. In order to perform this conversion, the incident neutron flux per monitor count must be known. This quantity is obtained for each incident energy by measuring the incoherent scattering from a vanadium sample in the same experimental setup. Since the vanadium scattering cross section is known, the incident flux per monitor count may be obtained. The vanadium measurements are also used to determine the resolution of the monochromator. The differential scattering cross sections for polyethylene and water were derived by integration of the inelastic cross section, $\partial^2\sigma/\partial\Omega\partial E$, over all final neutron energies. Results in the form of "scattering law," $S(\alpha,\beta)$ are also presented. Structure in the spectrum of neutron energies after scattering is related to the molecular energy levels of the scattering system. Knowledge of the molecular dynamics of the scattering system can therefore be inferred from experiments of the present type. The cross section results obtained for polyethylene and water were compared to several scattering models of both the free gas and bound atom type. Einstein frequency distributions were used for the latter. The theoretical curves were broadened for the experimental resolution before comparison. Significant disagreement was found, and an effort was made to explain these discrepancies and to suggest improvements in the scattering models. It is suggested that the scattering models can be improved by replacing the approximate Einstein levels by the actual frequency distributions and using computer programs which will perform the various numerical integrations thereby required. The delta function levels of an Einstein frequency distribution are shown to be a particularly poor approximation for the hindered rotations in water and the torsional and skeletal oscillations of the polyethylene molecule. (Dissertation Abstr.)

**2598** METHOD OF CALIBRATING NEUTRON SOURCES. Capgras, A. (CEN de Saclay, Gif-sur-Yvette, France). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/64, 14p. (In French). (CONF-660807-14). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The apparatus described is used calibrating neutron sources. An integration method based on manganese activation is used. The activation is not measured on samples (discontinuous method) but by a continuous method: a pump circulates the moderating solution around the detector from a 1-meter diameter sphere which contains the solution and in the center of which the neutron source is placed. The apparatus has various special features: maintenance of constant detector temperature; reheating of the solution by a thermostat placed at the input of the detector cell, which ensure good spectral stability for the period of 30 hours covered by the measurement. The activity of the source is calculated from a differential equation which gives the instantaneous activity of the manganese; this equation involves the use, among other parameters, of the circulation rate of the bath. Correction factors are calculated or measured, some of them being common to the differ-

ent types of source and others being specific. The apparatus is used to measure the activity of $\alpha-n$ sources of different types (Ra–Be, Pu–Be, Po–Be, Am–Be, Po–Li) with an accuracy varying between 2 and 1.1% for a neutron emission between $10^5$ and $10^7$ $ns^{-1}$. The accuracy obtained with the usual method of sampling would be between 7 and 2% owing to the large statistical error. The continuous method thus considerably improves the standard of the measurements. (auth)

# Nuclear Properties and Reactions, A≤ 5

*Refer also to abstracts 1582, 1593, 2651, 2673, and 2789.*

**2599** (BNL-10686) NUCLEAR STRUCTURE PHYSICS WITH 1-Bev PROTONS. Palevsky, H. (Brookhaven National Lab., Upton, N. Y.). Oct. 13, 1966. Contract AT(30-2)-Gen-16. 30p. (CONF-660906-38). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

The theoretical bases and the experimental arrangement for the use of 1-GeV protons in studies of nuclear structure are discussed, together with some observations of proton scattering by $^{12}C$, He, H, and $^{16}O$ and of the $^{12}C(p,d)^{11}C$ reaction. Some evidence for the existence of quasi-free n-p pairs in the C nucleus is presented. (D.C.W.)

**2600** (DESY-66/21) LOW MOMENTUM TRANSFER NEUTRON FORM FACTORS FROM ANALYSIS OF DEUTERON ELECTRODISINTEGRATION. Braess, D.; Hasselmann; Kramer, G. (Hamburg Univ. (West Germany). II. Institut fuer Experimentalphysik. Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). Sept. 1966. 21p. Dep. mn.

Electromagnetic form factors of the neutron are calculated from recent inelastic e-d scattering measurements which were performed at the quasi-elastic peak and at momentum transfers below 5 $f^{-2}$. The theory used in the analysis includes a realistic description of the deuteron structure and of the effect of interactions between the outgoing nucleons. It is found that the rescattering corrections are very important in this region of momentum transfer. Concerning the charge form factor $G_{2E}$ of the neutron, it is concluded that meaningful results cannot be given at the moment. The magnetic form factor of the neutron $G_{2M}/\mu_2$ comes out still larger than, but closer to, the magnetic form factor $G_{1M}/\mu_1$ of the proton compared to former analyses. More measurements around $q^2 = 1f^{-2}$ seem to be very interesting in this respect. (auth)

**2601** (UCRL-16964) NUCLEAR REACTION Q-VALUES. Maples, C.; Goth, G. W.; Cerny, J. (California Univ., Berkeley. Lawrence Radiation Lab.). July 1966. Contract W-7405-eng-48. 363p. Dep. mn. CFSTI $7.00 cy, $1.75 mn.

The results of some calculations of Q-values for gamma, nucleon, deuteron, triton, and ion reactions with nuclei from Z = 2 to 92 are tabulated. (D.C.W.)

**2602** THE ENERGY SPREAD OF NEUTRONS FROM THE $T(d,n)^4He$ REACTION. Breunlich, W. H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 224-8(1966). (In German).

The effect of small-angle multiple scattering of deuterons in the target on the spread of the neutron energy was theoretically investigated for deuteron energies of 150 and 200 keV at angles of 98°. The results are tabulated and show that at this angle the multiple scattering of deuterons is responsible for the spread of the neutron energy. An analysis of some experimental results shows that the discrepancies are caused by the neglect of the neutron energy spread. (J.S.R.)

**2603** ELECTROMAGNETIC STRUCTURE OF ATOMIC NUCLEI AND NUCLEONS. Urban, P.; Zingl, H. (Univ., Graz). Acta Phys. Austr., 23: 1-12(1966). (In German).

Recent experimental and theoretical data are reviewed to illustrate how electron scattering can yield knowledge on the charge distribution of nuclei, the electromagnetic structure of nucleons, and the electromagnetic structure of deuterons. (J.S.R.)

**2604** A STUDY OF THE NEUTRON-$^3$He INTERACTION AT 14.4 MeV. Antolkovic, B. (Inst. R. Boskovic, Zagreb); Cerineo, M.; Paic, G.; Tomas, P.; Ajdacic, V.; Lalovic, B.; van Oers, W. T. H.; Slaus. I. Phys. Lett., 23: 477-9(Nov. 21, 1966).

The interaction of 14.4 MeV neutrons with $^3$He nuclei was studied using a charged particle counter telescope set at 0°. An analysis of the $^3He(n,d)np$ deuteron spectrum was performed. Evidence regarding a possible virtual state of the three-nucleon system is summarized. (auth)

**2605** DISPERSION THEORY OF THE MAGNETIC DIPOLE PHOTODISINTEGRATION OF THE DEUTERON. Petrov, N. M. (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 301-5(Feb. 1966). (In Russian).

Dispersion theory and the nonlocal nuclear interaction potential of Yamaguchi (Phys. Rev.: 95: 1628 (1954)) are used to discuss the magnetic dipole disintegration of the deuteron with the unphysical singularities associated with the finite range of nuclear forces taken into account. A dispersion relation is derived for the matrix element for the magnetic dipole photodisintegration of the deuteron; and from it, with the aid of the condition that the scattering matrix be unitary, an integral equation for the matrix element is obtained. The exact solution of the integral equation is obtained; and, in order to determine the effects of the unphysical singularities, approximate solutions are found in which one or both of the unphysical singularities are neglected. The results, together with those obtained elsewhere using different methods, are presented as curves giving the magnetic dipole photodisintegration cross section as a function of energy. The effect of the unphysical singularity associated with the finite range of nuclear forces in the singlet (triplet) state is to increase (decrease) the cross section; the cross section calculated by omitting both of the unphysical singularities is very close to that calculated by taking both of them into account. (ATD)

**2606** DIPOLE PHOTOABSORPTION IN $^6$Li. Kurdyumov, I. V.; El Samarai, S. Kh.; Smirnov, Yu. F.; Shitikova, K. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 292-300(Feb. 1966). (In Russian).

The translation invariant oscillator potential shell model of Smirnov and Shitikova was used to calculate the dipole photoabsorption of $^6$Li as well as the cross section for the $^6Li(\gamma,n)^5Li$ reaction. Excitation probabilities in the $^7Li(p,2p)^6He$ reaction of odd $^6$He states analogous to the $^6$Li states of interest in connection with the photoabsorption were also calculated by the method of Balashov and Boyarkina (Nucl. Phys., 38: 629 (1962)) and Dietrich (Phys. Lett., 2: 139 (1962)), and the energies of the $^6$Li states were determined by comparing the $^6$He calculations with experimental data. The photoabsorption calculations were effected by diagonalizing, together with the spin-orbital interaction, the matrix for the residual two-particle interactions, assumed to have a Gaussian radial dependence. The calculations were performed for the two exchange force variants of Serber and Rosenfeld and for several values of the spin-orbital coupling constant. The results did not depend strongly either on the spin-orbital coupling or on the exchange-force variant. The energy of one $^6$Li state was evaluated to be 16.6 Mev by comparing the $^6$He calculations with the experimental data of Garron et al., (Phys. Rev. Lett., 7: 261 (1961)) on the $^7Li(p,2p)^6He$ reaction, and three groups of $^6$Li photoabsorption levels were found in the 10 to 12, 16 to 25, and 31 to 35 Mev regions. It is concluded that it is possible to locate in a unified way with the aid of the present model all three groups of $^6$Li levels that are observed to be excited in dipole photoabsorption. According to the present calculations the only $^6$Li levels that can disintegrate into a $^3$He nucleus and a triton have energies between 16 and 18 Mev. Therefore, the conclusion of Makhnovskiy and Komar that these levels are located in the 21 to 23 Mev region is doubtful, and further experimental investigation of the photodisintegration of $^6$Li is desirable. (ATD)

**2607** MAGNETIC HYPERFINE FIELDS ACTING ON HEAVY NUCLEI RECOILED INTO IRON, COBALT, AND NICKEL. Gilad, P. (Weizmann Inst. of Science, Rehovoth, Israel); Goldring, G.; Kalish, R.; Herber, R. H. Phys. Rev., 151: 281-8(Nov. 4, 1966).

Hyperfine fields acting on heavy nuclei recoiled into magnetic lattices following Coulomb excitation were measured for $^{184,186}W$ and $^{148}Nd$ in iron, cobalt, and nickel lattices by means of angular-distribution or double-ratio measurements on the de-excitation gamma radiation. From such measurements both the magnitude and the sign of the hyperfine field can be determined. Moreover, information concerning the time scale on which the hyperfine field is established can be deduced by making the assumption that for pure rotational states $g_{2+} = g_{4+}$. From the internal consistency of the data for 2+ and 4+ levels in $^{182}$W and $^{184}$W and the 2+ level in $^{186}$W, it can be concluded that electronic and magnetic relaxation effects in magnetic lattices are short compared to the lifetime of the 4+ state in $^{184}$W ($6 \times 10^{-11}$ sec), although the data on the 4+ state in $^{186}$W ($4 \times 10^{-11}$ sec) suggest an upper limit to such relaxation times. The ratio of the hyperfine fields acting on tungsten recoiled into iron and cobalt is 1 : 0.7 in good agreement with published data for other transition elements in these matrices. The sign of the hyperfine field is negative in the case of tungsten and positive in the case of neodymium guest atoms. (auth)

**2608** NUCLEAR INFORMATION DERIVED WITH THE AID OF THE MOESSBAUER EFFECT AND PERTURBED ANGULAR CORRELATIONS. Klyucharev, V. A. (Physicotechnical Inst., Academy of Sciences, Ukrainian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2130-40(Dec. 1965). (In Russian).

A survey on the use of the Moessbauer effect and perturbed

angular correlations to derive nuclear spectroscopic data is presented. Particular attention is given to the measurement of magnetic dipole and electric quadrupole moments of short-lived nuclear states. Both techniques involve two successive transitions with a common intermediate state; in the Moessbauer effect the initial and final states of the cascade process are also identical. Information can be derived concerning the influence of both intra- and extranuclear factors on the intermediate state. The angular correlation is sensitive to the time integral of the perturbation over the life of the intermediate state, whereas Moessbauer scattering carries information concerning the value of the perturbation only at the instant of the transition. In addition to measuring magnetic dipole and electric quadrupole moments, one can employ both techniques to measure lifetimes, spins, and particles of excited states and angular momenta of the radiation. Information concerning nuclear structure can be derived from beta-gamma correlations and, using the Moessbauer effect, from isomeric shifts. Finally, one can derive non-nuclear information from the relative probability of recoil-free absorption and radiation. Between the two methods the advantage usually lies with the perturbed angular correlation technique; this method has the wider range of applicability and greater capability for resolving the components of nuclear levels that have been split in external fields. The energy resolving power of the two methods is investigated, and it is concluded that the resolving power of the angular correlation technique is greater than that of the Moessbauer effect by a factor 10 for levels that have been split in an electric field and by a factor 100 for levels that have been split in a magnetic field. The magnetic moments of 57 short-lived nuclear levels and the electric quadrupole moments of 6 levels are tabulated. The half lives of these levels, whose moments were measured by the two techniques, range from 0.007 to 153 nanosec. The interference effects observed in Coulomb excitation are briefly discussed. It is suggested that similar effects are to be expected in charged particle emission and that one should be able to determine quadrupole moments by comparing alpha-gamma and gamma-gamma correlations of cascade processes having the same intermediate state. (ATD)

**2609** THE T(d,n)$^4$He REACTION AT LOW ENERGIES. Huq, A. (Atomic Energy Center, Dacca, East Pakistan). Helv. Phys. Acta, 39: 507-12(1966).

Recent measurements of the differential cross sections with polarized deuterons showed some deviation from the s-wave-resonance description of the reaction above 300-keV deuteron energy. An investigation was made into the contributions coming from the interference of broad, unspecified, overlapping states with the resonance $^3/_2{}^+$ state, for $E_d$ = 500 keV. The efficiency parameters $P_{33}^d$ and $P_{11}^d - P_{22}^d$ are compared with the observed values at a nearby energy $E_d$ = 580 keV. (auth)

**2610** SINGLE-PARTICLE STATES OF THE MASS-4 NUCLEI. Spicer, B. M. (Univ. of Melbourne). Austral. J. Phys., 19: 705-7(Oct. 1966).

The excited states of $^4$He were previously studied as final-state interactions between outgoing protons and tritons in the reaction $^3$He(d,p)$^4$He. The results of an attempt to interpret the excited states of $^4$He within the framework of single-particle excitations in the particle-hole model of $^4$He are presented. (D.C.W.)

**2611** COUPLED-CHANNEL SCHROEDINGER-EQUATION MODEL FOR NEUTRON–ALPHA AND DEUTERON–TRITON SCATTERING. I. De Facio, B.; Umerjee, R. K.; Gammel, J. L. (Texas A and M Univ., College Station). Phys. Rev., 151: 819-26(Nov. 18, 1966).

A two-body model for neutron-alpha and deuteron-triton scattering is considered in which pairs of states are coupled together by a real, central, Saxon potential. All couplings obey conservation of total angular momentum and parity. The $D_{\frac{5}{2}}$ excited state of $^5$He (or the 107-keV "resonance" in the d + T system) is thus explained by a strong coupling. This simple model adequately explains the elastic and reaction data except for the low-angle left-right asymmetry for the (mirror) reaction proton. (auth)

**2612** NEUTRON FORM FACTORS FROM INELASTIC ELECTRON SCATTERING IN TRITIUM AND $^3$He. Hughes, E. B.; Yearian, M. R.; Hofstadter, R. (Stanford Univ., Calif.). Contract Nonr 225(67). Phys. Rev., 151: 841-5(Nov. 18, 1966).

Measurements are reported of the inelastic scattering of electrons from the mirror nuclei of tritium and $^3$He. The ratio of the quasi-elastic electron-tritium and electron-$^3$He cross sections was measured to a precision of about 3% for values of the square of the four-momentum transfer $q^2$ equal to 2.5 and 4.6 $F^{-2}$. Detailed measurements of the shape of the entire inelastic spectra and estimates of the total inelastic cross sections were also made. While these data are primarily intended to furnish additional experimental information which will be of use in determining the structure of the three-body nuclei, it is also pointed out that such data are a possible source of information on the structure of the neutron. (auth)

**2613** CHARGE-INVARIANT ANALYSIS OF NUCLEON SCATTERING EXPERIMENTS ON A = 3 NUCLEI. Barit, I. Ya.; Sergeev, V. A. (Lebedev Inst. of Physics, Moscow). Yadern. Fiz., 4: 712-19(Oct. 1966). (In Russian).

The charge-invariant phase-shift analysis of a number of experiments on the direct and charge-exchange scattering of 0- to 1.7-MeV (center of mass system) nucleons on A = 3 nuclei was performed. Spin-orbital interaction and the contribution of $l \geq 2$ waves were neglected. The S-matrix elements for l = 0, I = 0 and 1 were determined, describing the experimental scattering cross sections at $\theta_{cms}$ = 90° with an accuracy ~10%. The analysis confirms the existence of a virtual level in $^4$He with $J^\pi = 0^+$, T = 0 below the (p,n) reaction threshold and indicates the importance of taking the spin-orbital interaction into account for energies >1.1 MeV. (auth)

**2614** ROLE OF INTERACTIONS BETWEEN FINAL STATE NUCLEONS IN THE COMPLETE PHOTODISINTEGRATION OF THREE-PARTICLE NUCLEI. Fetisov, V. N. (Lebedev Inst. of Physics, Moscow). Yadern. Fiz., 4: 720-7(Oct. 1966). (In Russian).

The energy spectra and angular distributions of nucleons in the complete photodisintegration reaction of three-particle nuclei are discussed. It is shown that the singlet interaction of pairs of final-state nucleons significantly influences the form of the spectra. (auth)

**2615** DEUTERON TENSOR POLARIZATION IN p-d ELASTIC SCATTERING. Young, P. G.; Ivanovich, M. (Australian National Univ., Canberra). Phys. Lett., 23: 361-3(Nov. 7, 1966).

The deuteron tensor polarization in p-d elastic scattering was measured at a total of eight proton energies between 3.4 and 9.8 MeV for laboratory scattering angles of 22.5 and 30°. The measurements indicate that some of the polarization tensors are significantly different from zero. (auth)

**2616** THE STUDY OF THE REACTION D(p,2p)n AT 46 MeV. Slaus, I. (Univ. of California, Los Angeles); Verba, J. W.; Richardson, J. R.; Carlson, R. F.; August, L. S.; Petersen, E. L. Phys. Lett., 23: 358-60(Nov. 7, 1966).

Correlation spectra from the p + d breakup reaction were measured at 46 MeV. The data, which show pronounced effects due to final-state interactions and quasi-free processes, were analyzed in terms of three different spectator model calculations and the Chew-Low extrapolation procedure. (auth)

**2617** COULOMB DISPLACEMENT ENERGIES OF NUCLEI. Harchol, M.; Jaffe, A. A.; Miron, J.; Unna, I.; Zioni, J. (Hebrew Univ., Jerusalem). Nucl. Phys., 6701A: 459-72(1967).

The systematic trends in the Coulomb displacement energies of many nuclei with mass numbers up to 145 are presented and are discussed. Calculations based on the shell model were made for 32 nuclei in the region 28 < A < 65; these yield close quantitative agreement with the experimental results. The masses of 24 nuclei having an excess of protons are predicted and almost all are found to be stable against heavy particle emission. Most of these nuclei have not yet been identified experimentally. A compilation of accurately known Coulomb displacement energies is given. (auth)

**2618** SCATTERING OF POLARIZED PROTONS BY HELIUM FROM 0.9 TO 3.2 MeV. Brown, Louis (Carnegie Institution of Washington, D. C.); Traechslin, Walter. Nucl. Phys., 6701A: 334-8(1967).

Polarized protons were scattered from $^4$He. The left–right asymmetry was observed at 110 points for energies from 0.94 to 3.2 MeV and for laboratory scattering angles from 30° to 140°. (auth)

**2619** PHASE SHIFTS AND POLARIZATION IN PROTON–ALPHA SCATTERING FROM 0.9 TO 3.2 MeV. Brown, Louis (Carnegie Institution of Washington, D. C.); Haeberli, W.; Traechslin, Walter. Nucl. Phys., 6701A: 339-52(1967).

Some measurements of the left–right asymmetry in proton–alpha scattering are analyzed to determine the polarization of the proton beam and to find the phase shifts that best reproduce the polarization and cross section for proton energies below 3.2 MeV. The phase shifts agree with the earlier ones of Critchfield and Dodder, but the new measurements allow a much more accurate determination of the p-wave splitting. The p-wave phase shifts that best fit the experimental data are determined for various assumed values of the s-phase. The effect of d-waves is also investigated. Systematic searches for other sets of phases yield only the previously known four sets, if cross section data alone are used, and four sets, if polarization data alone are used. Only one set satisfies both cross section and polarization data. The polar-

ization calculated from the new phase shifts is presented as a contour map. (auth)

**2620** ANGULAR DISTRIBUTION OF PHOTOPROTONS FROM DEUTERIUM. Liles, Barry Jerome. New Haven, Yale Univ., 1966. 146p.

Thesis.

The angular distribution of photoprotons from the reaction D(γ,p)n was measured in the photon energy range from 30 to 60 Mev. The measurement used a $^2$H gas target at 3 atoms, absolute with thick lithium-drifted silicon detectors at 15° intervals from 30 to 165° in the laboratory system. Gold-lined slit systems accurately established the target geometry with an angular definition of ±4° at each detector. Due to experimental difficulties it was not possible to obtain absolute cross sections. Angular distributions are presented at 5-Mev intervals from 30 to 60 Mev. The present results are compared with recent theoretical calculations, and with previous experimental results. The present results were found to be generally more symmetrical (less forward peaking) than the theoretical predictions. (Dissertation Abstr.)

## Nuclear Properties and Reactions, 6 ≤ A ≤ 19

*Refer also to abstracts 1593, 2599, 2601, 2603, 2608, 2617, 2651, 2652, 2673, 2771, 2779, 2807, and 2808.*

**2621** (AD-634869) ENERGY AND ANGULAR CORRELATIONS IN THE $^{12}$C(p,2p)$^{11}$B REACTION AT 45.5 MeV. Richie, Kenneth E. (California Univ., Los Angeles. Dept. of Physics). May 1966. Contract Nonr-233(44). 99p. (TR-P-75). CFSTI $3.00 cy, $0.75 mn.

The angular correlation of the two protons emitted from the $^{12}$C(p,2p)$^{11}$B reaction at 45.5 MeV was measured with one detector fixed at 30° and the other rotated from 20° to 140°, in steps of 10°, on the opposite side of the beam line. The energy sharing of the two protons was also determined, using two dimensional analysis by an on-line computer system. The results were fit with a computer program based on the distorted wave theory. (auth)

**2622** INVESTIGATION OF ELASTIC SCATTERING OF 70-MeV ELECTRONS ON $^{12}$C AND $^9$Be AND THE MEAN SQUARE RADII OF THOSE NUCLEI. Afanas'ev, N. G.; Startsev, V. I.; Smelov, E. M.; Kuplennikov, E. L.; Stepula, E. V.; Petrenko, V. V.; Fursov, G. L. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 371-7(Feb. 1966). (In Russian).

The elastic scattering cross sections of $^{12}$C and $^9$Be for 70-Mev electrons at different scattering angles between 30 and 150° were measured in order to evaluate the root-mean square radii of the nuclei. The 70-Mev electron energy was chosen for the measurements because at that energy the momentum transfers are high enough to permit determining the momentum transfer dependence of the form factor, and yet low enough to allow of neglecting higher powers than the second (of the momentum transfer) in the expression for the form factor. The electron beam was produced by a pulsed accelerator. The primary beam intensity was measured with a secondary emission monitor which was calibrated with a Faraday cup. The electrons that were elastically scattered at a given angle from the graphite, polyethylene, or beryllium foil target were focused with a magnetic field onto a Čerenkov counter which recorded them. The scattering angle at which scattered electrons were recorded could be changed without breaking the vacuum. In addition to the measurements with the Čerenkov counter measurements were realized with photographic recording of the scattered electrons. Although some of the corrections involved in the different techniques are different (the corrections are discussed at some length), the cross sections measured by the two different recording methods were in excellent agreement. The values obtained from the momentum transfer dependence of the form factor for the rms radii of $^9$Be and $^{12}$C were 2.26 ± 0.1 and 2.35 ± 0.01 fermi, respectively. (ATD)

**2623** EXPERIMENTAL STUDY OF THE REACTIONS $^9$Be(α,n)$^{12}$C, $^{13}$C(α,n)$^{16}$O, AND $^6$Li(α,d)$^8$Be AND THEIR INTERPRETATION BY THE THEORIES OF DIRECT INTERACTION. Deconninck, G. (Univ., Louvain, Belg.). Acad. Roy. Belg. Cl. Sci., Mem.: Collect. in 8, 35: No. 2, 1-76(1965). (In French).

Some measurements of the angular distributions for the reactions $^9$Be(α,n)$^{12}$C, $^{13}$C(α,n)$^{16}$O, and $^6$Li(α,d)$^8$Be are summarized, together with analyses of the results by the theory of resonances and the theories of direct interaction. Interference with resonant scattering as well as the possibility of a local resonant mechanism are proposed to take into account the rapid variations with energy of the alpha cross sections. (D.C.W.)

**2624** THE EFFECT OF A DEFORMED CENTRAL POTENTIAL ON THE GIANT RESONANCE IN $^{16}$O. Kluge, G. (Technische Hochschule, Darmstadt, Ger.). Z. Phys., 197: 288-99 (1966). (In German).

A deformed self-consistent field is assumed in order to explain the splitting of the giant dipole resonance of $^{16}$O in terms of one particle excitations. The calculated energies and dipole strengths of states above 20 Mev agree with experiments for a deformation parameter δ of approximately 10%. (auth)

**2625** INTERACTIONS OF A 29-MeV $^3$He PARTICLE BEAM WITH $^{16}$O. II. INELASTIC SCATTERING AND ($^3$He,p) AND ($^3$He,d) PICKUP REACTIONS. Aguilar, J.; de la Rubia, J.; Sanchez, A.; Martinez, R. (Facultad de Ciencias, Madrid). An. Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 62: 279-83(Sept.-Oct. 1966). (In Spanish).

The energy levels of $^{17}$F, $^{18}$F, $^{15}$O, and $^{15}$O were investigated through ($^3$He,d), ($^3$He,$^4$He), and ($^3$He,p) reactions on $^{16}$O and through $^3$He inelastic scattering by $^{16}$O. (D.C.W.)

**2626** INELASTIC SCATTERING OF ELECTRONS ON $^9$Be AND A COMPARISON OF DIFFERENT NUCLEAR MODELS. Kudeyarov, Yu. A.; Neudachin, V. G.; Smirnov, Yu. F. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 235-41(Feb. 1966). (In Russian).

The form factor of $^9$Be for electron inelastic scattering was calculated using a nucleon cluster model. The form factor obtained was in excellent agreement with experimental data while a form factor calculated using the Bohr-Mottelson unified model was not. It was concluded that the spatial correlations among the nucleons described by the cluster model are real. (D.C.W.)

**2627** MUON CAPTURE AND SUPERMULTIPLET SYMMETRY BREAKING IN $^{16}$O. Walker, George Edward (Los Alamos Scientific Lab., N. Mex. Case Inst. of Tech., Cleveland). Contract W-7405-eng-36. Phys. Rev., 151: 745-60(Nov. 18, 1966). (LA-DC-7992).

The validity of assuming the equality of the unretarded-dipole muon-capture matrix elements, $(M_V{}^2)_{U,D_r}$, $(M_P{}^2)_{U,D_r}$, and $(M_A{}^2)_{U,D_r}$ is investigated for muon capture in $^{16}$O. Previously supermultiplet theory was used to obtain $(M_V{}^2)_{U,D_r} = (M_P{}^2)_{U,D_r} = (M_A{}^2)_{U,D_r}$. Therefore, the correctness of a supermultiplet grouping of the important muon-capture nuclear final states when realistic supermultiplet-symmetry-breaking interactions are included in the nuclear Hamiltonian is considered. Basic wave functions are taken to be simple harmonic-oscillator shell-model LS-coupled states belonging to the $(1p)^{-1}2s$ and $(1p)^{-1}1d$ configurations of $^{16}$O. It is found that all particle-hole states of interest for muon capture belong to vector supermultiplets. These states will not be mixed with the other supermultiplet type (scalar) of the configuration if isotopic spin is a good quantum number. Energy eigenvalues and eigenfunctions of various nuclear Hamiltonians are obtained by diagonalizing the residual interaction matrices that mix the simple basic states. The results indicate that the spin-independent interparticle forces isolate the unretarded-dipole muon-capture strength in the supermultiplet lying highest in energy. The energy difference between this supermultiplet and lower-lying supermultiplets has a tendency to suppress the large amount of supermultiplet mixing one might expect in the giant-resonance region when tensor and spin-orbit forces are added to the Hamiltonian. Therefore, it is found that the muon-capture strength remains concentrated in the giant-dipole region and that the muon-capture supermultiplet remains substantially pure. In all cases, $(M_V{}^2)_{U,D_r} = (M_P{}^2)_{U,D_r} = (M_A{}^2)_{U,D_r}$ remains a valid assumption to within 12%. (auth)

**2628** MEASUREMENT OF THE g FACTOR OF THE 1+583-keV STATE IN $^{22}$Na USING THE $^{19}$F($^{210}$Po α,n)$^{22*}$Na REACTION. Sunyar, A. W.; Thieberger, P. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Phys. Rev., 151: 910-11 (Nov. 18, 1966). (BNL-10352).

The $^{19}$F(α,n)$^{22}$Na* reaction which takes place in a source of $^{210}$Po dissolved in HF was used to prepare $^{22}$Na* in the 0.66-MeV 0+ excited state. The subsequent 0+ → 1+ → 3+ γ−γ angular correlation was magnetically perturbed in order to measure the g factor of the 0.58-MeV first excited state. A value g = +0.535 ± 0.010 was obtained. The energy and half life of the 1+ state were measured to be 583.0 ± 0.5 keV and 243 ± 2 × $10^{-9}$ sec, respectively. (auth)

**2629** ELASTIC SCATTERING OF π MESONS ON CARBON AT 5 TO 22 MeV. Demidov, V. S.; Kirillov-Ugryumov, V. G.; Ponosov, A. K.; Protasov, V. P.; Sergeev, F. M. pp 41-7 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The differential cross sections and angular distributions for mesons (π) elastic scattering on $^{12}$C nuclei at 5 to 22 MeV were measured using the pion beam from the JINR synchrocyclotron. Theoretical cross sections were calculated and were compared with the experimental results. Very good agreement between theory

and experiment was found between both the cross-section and the angular-distribution data. (G.O.Y.)

**2630** INVESTIGATION OF THE MASS SPECTRA OF SINGLY CHARGED PARTICLES FROM MESON ($\pi^+$) ABSORPTION IN NUCLEAR EMULSIONS. Fesenko, A. I.; Sergeev, F. M.; Wang, Kuo-yen. pp 100-1 of Fizika Elementarnykh Chastits. Mikhailov, V. D.; Rozental, I. L. (eds.). Moscow, Atomizdat, 1966. (In Russian).

The mass spectra of singly charged particles resulting from collision of a 410-MeV/c $\pi^+$ beam on 100 layers of P emulsion was measured. The relative number of charged particles present was measured by the ionization parameter method which characterizes the mass of the particles. The results consisted of 60% protons, 22% deuterons, and 18% tritons. The results agreed with the theoretical results obtained by Weisenberg et al. (G.O.Y.)

**2631** PRECISION MEASUREMENTS OF NUCLEAR REACTION CALIBRATION ENERGIES. Roush, M. L.; West, L. A.; Mullendore, J. V.; Fann, H. L.; Marion, J. B. (Univ. of Maryland, College Park). Phys. Lett., 23: 355-7(Nov. 7, 1966).

Precision measurements of the $^{27}Al(p,\gamma)^{28}Si$ resonance energy and the $^{7}Li(p,n)^{7}Be$ threshold energy were made using an absolute velocity technique. The results are, respectively, 991.912 ± 0.043 and 1880.617 ± 0.078 keV. A precision of 1 part in $10^4$ in such measurements was exceeded for the first time. (auth)

**2632** MIXING RATIOS IN THE GROUND-STATE DECAYS OF THE 3.68- AND 3.85-MeV LEVELS OF $^{13}C$. Poletti, A. R.; Olness, J. W.; Warburton, E. K. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Phys. Rev., 151: 812-18(Nov. 18, 1966). (BNL-10291).

The mixing ratios for two gamma transitions in $^{13}C$ were measured. For the transition 3.68 → 0, x(E2/M1) = −0.096 while for the transition 3.85 → 0, x(E3/M2) = +0.12 ± 0.03. The phase convention quoted by Poletti and Warburton is used. The phase of the mixing ratio for the 3.68 → 0 transition is compared with that for the mirror transition in $^{13}N$ and with the phase of the mixing ratio for the transitions between $\frac{3}{2}^-$ and $\frac{1}{2}^-$ hole states in $^{15}N$ and $^{15}O$. The 3.85 → 0, $\frac{5}{2}^+ \rightarrow \frac{1}{2}^-$ transition is also discussed and is compared with the $\frac{5}{2}^+ \rightarrow \frac{1}{2}^-$ transitions in mass 15. (auth)

**2633** STUDIES OF $^{18}F$ FROM THE $^{16}O(^3He,p\gamma)^{18}F$ REACTION. Olness, J. W.; Warburton, E. K. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Phys. Rev., 151: 792-811(Nov. 18, 1966). (BNL-10282).

The Doppler-shift attenuation method was used to investigate the lifetimes of various gamma-emitting states of $^{18}F$ populated via the $^{16}O(^3He,p\gamma)^{18}F$ reaction at a $^3He$ bombarding energy of 3.4 MeV. Gamma spectra were measured with a lithium-drifted germanium spectrometer for detection angles $\theta_\gamma = 8°$ and $\gamma_\gamma = 172°$ relative to the incident beam direction. The results determine the mean lifetimes (in picoseconds) for the levels of $^{18}F$, identified by their excitation energies (in MeV) as follows: 1.70 (0.86 ± 0.20); 2.10 (4.1 ± 1.6); 2.53 (0.67 ± 0.18); 3.06 (<0.17); 3.35 (0.46 ± 0.10); and 3.84 (<0.073). For each of the four longer-lived levels, the mean life was also determined from a theoretical fit to the experimental line shapes; these results have been incorporated in the values quoted for the 1.70-, 2.10-, 2.53-, and 3.35-MeV levels. The particle-gamma angular-correlation method for Litherland and Ferguson was used to gain information on the decay modes and spin assignments of the levels of $^{18}F$ below an excitation energy of 3.4 MeV. Protons were detected with an annular counter at 180° to the $^3He$ beam, and gamma rays were detected at several angles between 0 and 90° to the beam. Measurements were carried out for $^3He$ bombarding energies of 3.44, 4.65, and 5.40 MeV. These results establish spin assignments of J = 2 for both the 2.10- and 3.06-MeV levels of $^{18}F$, and are consistent with or confirm previously established spin-parity assignments for the remaining levels as follows: 0.937 ($3^+$), 1.70 ($1^+$), 2.53 ($2^+$), 3.13 (1), and 3.35 (2 or 3). It is further established that the 2.10- and 1.08-MeV levels have the same parity. The most probable spin of the 1.08-MeV level is found to be J = 0 (although J = 1 or 2 are not excluded) in which case the lifetime determined for the 2.10-MeV level establishes that the 2.10 → 1.08 transition are an enhanced E2 of strength approximately 20 Weisskopf units. Additional information was obtained for the mixing ratios of various ground-state and cascade transitions in $^{18}F$. (auth)

**2634** DIFFERENTIAL CROSS SECTIONS AND EXCHANGE EFFECTS IN THE REACTION $^{19}F(d,n)^{20}Ne$. Warshaw, Stephen I.; Goldberg, D. A.; Owen, George E. (Johns Hopkins Univ., Baltimore). Phys. Rev., 151: 834-40(Nov. 18, 1966).

Angular distributions of neutrons from the reaction $^{19}F(d,n)^{20}Ne$ in the ground and first excited states were measured at deuteron bombarding energies of 1.0, 1.5, 2.0, 2.2, and 2.5 MeV. Excitation functions at 0° were measured in 100-keV steps from 0.9 to 2.7 MeV. The differential cross section for production of first-excited-state neutrons was measured to be 7.4 ± 0.8 mb per steradian at 0° with a beam energy of 2.00 MeV. A single stilbene crystal employing pulse-shape discrimination was used to detect the neutrons. The angular distributions were analyzed in terms of a dual-mode plane-wave theory which formally incorporates exchange and interference terms. It is found that the gross features of the distributions as a function of energy can be qualitatively accounted for by this model. Both excitation functions exhibit fluctuations which include a broad peak at 2 MeV that also appears to be present in the total cross section for the first-excited-state neutrons. It is tentatively proposed that this suggests the presence of groups of closely spaced levels of unusually high excitation of $^{21}Ne$. (auth)

**2635** $^8Be$ LEVELS AT 16.62 AND 16.92 MeV FROM $^6Li(^6Li,\alpha)^8Be$. Mancusi, M. D.; Norbeck, E. (Univ. of Iowa, Iowa City). Phys. Rev., 151: 830-3(Nov. 18, 1966).

Angular correlations in the reaction plane for the 16.62- and 16.92-MeV, $J^\pi = 2^+$ states in $^8Be$ were measured for the reaction $^6Li(^6Li,\alpha_1)^{8*}Be \rightarrow 2\alpha$ at a bombarding energy of 5.5 MeV with $\alpha_1$ detected at 15° in the lab. The correlations for the two states are identical to a multiplicative factor at all decay alpha angles. Another alpha-alpha coincidence run at 5.0-MeV bombarding energy was performed to measure the ratio of intensities of these two states. The same data show a peak which may represent a 19.9-MeV $^8Be$ state with a width of 1.3 MeV. In addition, measurements of the ratio of the differential cross sections of the 16.62- and 16.92-MeV levels over a range of bombarding energies from 4.3 to 5.5 MeV indicate that the relative intensity of the 16.62-MeV level to that of the 16.92-MeV level is a constant equal to 1.22 ± 0.08. These results favor a description of these states as strongly mixed in isobaric spin. (auth)

**2636** ASYMMETRY OF ANGULAR DISTRIBUTION OF PRODUCTS OF THE $^{12}C(d,d)^{12}C$ REACTION WITH POLARIZED DEUTERONS. Malko, A. I.; Soroka, V. A. (Inst. of Physics and Tech., Academy of Sciences, Ukrainian SSR). Ukr. Fiz. Zh., 11: 904-5(1966). (In Ukrainian).

The various asymmetries and polarizations in the elastic scattering of polarized deuterons by $^{12}C$ were evaluated. (D.C.W.)

**2637** PARTICLE-HOLE STATES IN $^{16}O$. Federman, P. (Niels Bohr Inst., Copenhagen); Kelson, I. Phys. Rev. Lett., 17: 1055-7(Nov. 14, 1966).

The particle-hole states resulting from promoting two $p^h$ nucleons to the s-d shell, in conjunction with a total decoupling of the deformed states from the spherical states, were studied theoretically. The effect of including states where one $p^h$ nucleon is promoted to the p-f shell was found to be small. (D.C.W.)

**2638** ANGULAR-CORRELATION STUDIES OF THE REACTIONS $^{12}C(^3He,\alpha)^{11}C$ AND $^{16}O(^3He,\alpha)^{15}O$. Gallmann, A.; Haas, F.; Balaux, N. (Laval Univ., Quebec). Phys. Rev., 151: 735-44 (Nov. 18, 1966).

The 4.32- and 4.81-MeV levels of $^{11}C$ and the 6.79- and 6.86-MeV levels of $^{15}O$ were studied using the particle-gamma angular-correlation method of Litherland and Ferguson. The spin of the $^{11}C$ 4.32-MeV level was established to be $\frac{5}{2}$ and the mixing ratio for the transition 4.32 → 0 was measured: $\delta = +(0.16^{+0.05}_{-0.04})$. A probable spin assignment $J = \frac{3}{2}$ was determined for the $^{11}C$ 4.81-MeV level. For this assignment, the mixing ratios of the 4.81 → 2.0 and 4.81 → 0 transitions were obtained. A spin assignment of $J = \frac{3}{2}$ was confirmed for the $^{15}O$ 6.79-MeV level. The $^{15}O$ 6.86-MeV level probably has a spin $J = \frac{5}{2}$, but $J = \frac{3}{2}$ can not be eliminated. The mixing ratios for the 6.86 → 5.24 ($\frac{5}{2} \rightarrow \frac{5}{2}$) and the 5.24 → 0 ($\frac{5}{2} \rightarrow \frac{1}{2}$) transitions were found. The results are compared with previous experiments and theoretical predictions. (auth)

**2639** (d,p) REACTION ON $^{12}C$ AT LOW DEUTERON ENERGIES. Klyucharev, A. P.; Titov, Yu. I. (Kharkov State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 224-8(Feb. 1966). (In Russian).

The differential cross section for the $^{12}C(d,p)^{13}C$ reaction was measured at deuteron energies from 0.5 to 1.8 MeV. The detector was shielded with a 19.6 mg/cm² aluminum foil to eliminate the elastically scattered deuterons. Energy calibration was effected with the aid of a $^{210}Po$ source mounted in the scattering chamber. The energy scatter of the deuteron beam was less than 10 keV. A thin unbacked carbon target was employed; its thickness, defined in terms of 0.75-MeV protons elastically scattered at 70°, amounted to 5 to 7 keV at different energies. Excitation functions of the reaction at three different angles and the differential cross section as a function of angle at 10 different deuteron energies are presented graphically. The angular distributions were expressed as sums of Legendre polynomials, and the coefficients of the polynomials are presented graphically as functions of the deuteron energy. Five Legendre polynomials were adequate to represent

the angular distributions, the ratio of the coefficient of $P_4$ to that of $P_0$ did not exceed 0.08. From the angular distributions it is concluded that over the investigated energy range the reaction goes via compound nucleus formation and the contribution of direct processes cannot exceed the 3% experimental error. Previously known resonances corresponding to excitation energies of the $^{14}N$ compound nucleus of 11.10, 11.29, 11.39, and 11.50 MeV were observed and the spin and parity assignments of Kashy, Perry, and Risser (Phys. Rev., 5: 117(1960)) were confirmed. A resonance was also observed corresponding to a compound-nucleus excitation of 11.72 MeV; the spin and parity of the 11.72-MeV $^{14}N$ state are $2^-$. (ATD)

**2640** ON THE SENSITIVITY OF THE $^{11}B(p,\gamma)^{12\,m}C$ AND $^{11}B(p,\alpha)^8Be$ REACTIONS NEAR THE 162-keV RESONANCE TO THE POLARIZATION OF THE PROTONS. Sorokin, P. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 220-3(Feb. 1966). (In Russian).

The sensitivity of the $^{11}B(p,\gamma)^{12\,m}C$ ($E_\gamma$ = 12 MeV) and $^{11}B(p,\alpha)^8Be$ (Q = 6.7 MeV) reactions to the polarization of the incident protons was calculated. The sensitivity to proton polarization of the $^{11}B(p,\gamma)$ reaction was found to depend on the difference between the phase shifts for different channel spins. There are no experimental data on such phase-shift differences; resonance reactions of the type under discussion would provide a suitable tool for investigating them. In the $^{11}B(p,\alpha)$ reaction there is considerable interference between the $2^+$ resonance level and a $1^-$ level with $l_p = 0$, as a result of which the reaction would be sensitive to the incident proton polarization even if the $^{11}B(p,\gamma)$ reaction were not. The calculated sensitivity of the $^{11}B(p,\alpha)$ reaction to proton polarization is presented graphically as a function of proton energy near the 162-keV resonance for a scattering angle of 45° and different values of the phase-shift difference. It is estimated that a 0.1-microamp polarized proton beam will be required for experimental investigation of the reactions. (ATD)

**2641** THE REACTIONS $^{14}N(n,\alpha)^{11}B$ AND $^{14}N(n,t)^{12}C$ OBSERVED WITH A GRIDDED IONIZATION CHAMBER. Scobel, W.; Fink, R. W.; Bormann, M. (Univ., Hamburg). Z. Phys., 197: 124-35(1966). (TID-23393).

The cross sections for the reactions $^{14}N(n,\alpha)^{11}B$ and $^{14}N(n,t)^{12}C$ have been measured in the neutron energy range 4.0 to 6.4 MeV and at 2.5 MeV. Monoenergetic neutrons were produced in the $D(d,n)^3He$ reaction using a gas target. The $(n,\alpha)$ and (n,t) disintegrations were detected in a gridded ionization chamber filled with an argon-nitrogen mixture. The response of the chamber under different operation conditions is described. The excitation functions, measured with a neutron energy resolution of 40 to 50 keV, are given for the $\alpha_2$ group from the $^{14}N(n,\alpha)^{11}B$ reaction over the entire neutron energy range and for the $\alpha_1$ group and the $t_0$ group from $^{14}N(n,t)^{12}C$ for neutron energies above 4.3 and 5.6 MeV, respectively. (auth)

**2642** SHELL MODEL CONFIGURATIONS OF STATES IN $^{14}N$ STUDIED BY THE $^{13}C(d,n)^{14}N$ REACTION. Fuchs, H.; Grabisch, K.; Kraaz, P.; Roeschert, G. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Phys. Lett., 23: 363-6(Nov. 7, 1966).

A $E_d$ = 6 MeV, energy spectra and angular distributions of neutrons from the $^{13}C(d,n)^{14}N$ reaction were measured; $l_p$ values and relative spectroscopic factors were extracted. The results confirm shell-model assignments to nine states in $^{14}N$ below 9 MeV. (auth)

**2643** INTERFERENCE BETWEEN THE 16.62 AND 16.92 MeV LEVELS IN $^8Be$. Browne, C. P. (Univ. of Notre Dame, Ind.); Callender, W. D.; Erskine, J. R. Phys. Lett., 23: 371-3 (Nov. 7, 1966).

The $^{10}B(d,\alpha)^8Be$ reaction reveals an asymmetry in the shapes of the alpha-particle groups corresponding to the 16.62- and 16.92-MeV states in $^8Be$. A simple two-level resonance formula which includes an interference term is found to fit the data. (auth)

**2644** ELASTIC SCATTERING OF 14-Mev NEUTRONS FROM CARBON, BORON, POTASSIUM, AND CALCIUM. Frasca, Albert Joseph. Athens, Ohio, Ohio Univ., 1966. 99p.

Thesis.

Neutron elastic differential cross sections were measured for carbon, boron, potassium and calcium. It should be noted that the cross-section is measured for an even-even nucleus and one of its neighboring odd-even nuclei. There should be little difference in the cross section for neighboring nuclei. With this in mind, the differential cross sections for the above mentioned nuclei were carried out. Also, the differential cross section for potassium had not been previously obtained. A time-of-flight system was used to obtain the angular distributions for the previously named materials. The electronic system had an overall time resolution of 1.3 nanoseconds. With a flight path of 1.68 meters, the resolution was sufficient to separate out any inelastic contributions. A complete discussion is given of the electronic system and associated equipment. The values for the cross sections obtained are in good agreement with previous works in the cases of boron, calcium, and carbon. The cross sections are C = 785 ± 30 mb, B = 938 ± 20 mb, K = 1038 ± 57 mb, and Ca = 918 ± 52 mb. The optical-model fits for the boron and carbon data were excellent. The potassium and calcium fits were also quite satisfactory. (Dissertation Abstr.)

**2645** THE PHOTOPROTON CROSS SECTIONS OF $^{16}O$ AND $^{12}C$. Morrison, Richard Charles. New Haven, Yale Univ., 1966. 143p.

Thesis.

The differential cross sections for the reactions of $^{16}O(\gamma,p)^{15}N$ and $^{12}C(\gamma,p)^{11}B$ were measured at 90° in the laboratory system, over the gamma energy ranges of 14.5 to 45 MeV and 17.2 to 48 MeV, respectively. Proton spectra were measured using silicon detectors in conjunction with a quadrupole triplet magnetic lens. Absolute cross sections were obtained by comparison with the $^2H(\gamma,p)n$ reaction. Transitions from the $^{16}O$ giant resonance to excited states in $^{15}N$ were investigated; the results indicate that the giant resonance levels decay only to ground state and the 6.33 MeV negative parity level in $^{15}N$. The experimental results are compared with other experimental results and with the predictions of particle-hole calculations. (Dissertation Abstr.)

**2646** INELASTIC PROTON SCATTERING IN THE 2s1d SHELL. Crawley, Gerard Marcus. Princeton, N. J., Princeton Univ., 1965. 209p.

Thesis.

The inelastic scattering of 17.5-MeV protons from a number of nuclei in the 2s1d shell was studied using lithium-drifted silicon detectors. The target nuclei were $^{16}O$, $^{19}F$, $^{23}Na$, $^{24}Mg$, $^{25}Mg$, $^{26}Mg$, $^{27}Al$, $^{28}Si$, $^{31}P$ and $^{32}S$. Four detectors were used simultaneously to increase the efficiency of taking data. The proton beam from the Princeton frequency modulated cyclotron had an energy resolution of 30 keV, and the total resolution of the system was typically about 50 keV. Extensive use was made of both the IBM 1620 and IBM 7094 computers in analyzing the data. Angular distributions were obtained for up to twenty energy levels in each nucleus. While many of these distributions were quite similar, there were a number of cases in even-A, even-Z nuclei where states with the same spin and parity had very different angular distributions. The angular distributions from the strongest levels were compared with the predictions of the distorted wave Born approximation. Good agreement was obtained for the first $2^+$ states in $^{24}Mg$, $^{28}Si$ and $^{32}Si$ and for many of the strong levels in $^{19}F$, $^{27}Al$ and $^{31}P$. Reasonable fits were also obtained for a number of $3^-$ states. The value of the transition strengths extracted from the comparison of the DWBA predictions with the data in general agreed reasonably well with the values from electromagnetic measurements. One notable exception was the value of the transition strength for the 1.35-MeV ($\frac{5}{2}^-$) level in $^{19}F$ which was a factor of three lower than the value extracted from a Coulomb excitation experiment. The relative cross sections determined in this experiment were also compared with the predictions of various nuclear models. The results for $^{23}Na$ and $^{25}Mg$ agreed quite well with a strong coupling nuclear model while $^{27}Al$ and $^{31}P$ were better explained by a weak coupling model. A number of previously unreported levels were observed in $^{23}Na$ (5.38, 5.75, and 5.94 MeV), $^{27}Al$ (7.23, 7.44, 7.66, 7.79, and 7.99 MeV), $^{31}P$ (5.34 and 5.67 MeV) and $^{32}S$ (5.41, 6.41, and 6.76 MeV). (Dissertation Abstr.)

**2647** ELASTIC SCATTERING OF DEUTERONS FROM $^{14}N$ BETWEEN 1.8 Mev and 5.5 Mev. Flinner, Jack LeRoy. Columbus, Ohio, Ohio State Univ., 1965. 127p.

Thesis.

The elastic scattering of deuterons from $^{14}N$ was studied with a differentially pumped gas scattering chamber. Excitation curves of the absolute differential cross sections between 1.8 and 5.5 MeV were determined at the cms angles of 90, 125.3, 140.8, and 166.6°, and nine angular distributions were measured between 2 MeV and 5.5 MeV in 500-keV steps. The angular distribution data are presented in the form of a ratio with the Rutherford differential cross section and is plotted as a function of the center of mass scattering angle. The reaction cross section for the many proton and alpha groups present was measured at 3 MeV by integrating over the angular distribution of the groups. Analysis of the experimental data was attempted with the optical model with both volume and surface absorption. Some structure was seen in the excitation curves which indicated six energy levels in the $^{16}O$ compound nucleus between 22.8 and 25.3 MeV. Two $V\text{-}R^2$ curves were determined for the real well depth and well radius with the other parameters remaining constant. Fits to the data were compared for well depths and radii belonging to these two curves. Large back angle scattering was found at the higher energies. The program used in the analysis does not have provisions for spin-orbit interactions

when the spin of the incident particle is greater than one-half and, therefore, no spin-orbit term was included in the optical model potential. As the reaction group peaks were observed during the progress of data taking, the alpha particle formed in the $^{14}N(d,\alpha)^{12}C$ reaction with a Q-value of 0.864 MeV was seen. Although this alpha particle was identified in other reactions, it appears that it has not been reported as being produced in the $^{14}N(d,\alpha)^{12}C$ reaction. (Dissertation Abstr.)

**2648** NUCLEAR TRANSFER REACTIONS AT HIGH ENERGY. Birnbaum, Joel Samuel. New Haven, Yale Univ., 1966. 173p.

Thesis.

Single nucleon transfer reactions resulting from the bombardment of carbon by 148-Mev nitrogen-14 ions were experimentally investigated in an attempt to elucidate the reaction mechanisms. The energy spectra of the $^{12}C(^{14}N,^{13}N)^{13}C$, $^{12}C(^{14}N,^{15}N)^{11}C$, and $^{12}C(^{14}N,^{15}O)^{11}B$ reactions, as well as those of the deuteron transfer reaction $^{12}C(^{14}N,^{16}O)^{10}B$ and the $^{14}N$-$^{12}C$ elastic and inelastic scattering were obtained simultaneously. Angular distributions corresponding to resolvable final states are presented. The one and two nucleon transfer reactions characterized by the highly selective population of only a few levels in the product nuclei are shown to be consistent with a reaction mechanism favoring the formation of states with dominant single particle configuration. Evidence is found for the most strongly excited levels being those for which the angular momentum transferred in the reaction most nearly matches that of the shell-model orbital into which the particle is transferred. The smooth angular distributions observed for all the transfer reactions are in disagreement with the predictions of the Frahn-Venter diffraction model, but may be qualitatively accounted for by the more recent theories of Dar and of Dodd and Greider. In consequence, it has not been possible to deduce the relative importance of nuclear and Coulomb reaction amplitudes, as inherent in the Frahn-Venter and similar diffraction reaction models. The $^{12}C(^{14}N,^{15}N)^{11}C$ and $^{12}C(^{14}N,^{15}O)^{11}B$ mirror reactions evidence similar energy spectra and angular distributions; within the present experimental accuracy, it appears that these reactions are charged independent. The elastic and inelastic scattering angular distributions display characteristic oscillations. The inelastic scattering mechanism is found to be highly selective, favoring collective residual excitations. (Dissertation Abstr.)

**2649** A STUDY OF SOME PROPERTIES OF EXCITED STATES IN LIGHT NUCLEI USING $^3$He-INDUCED REACTIONS. Lonergan, James Arthur. Tucson, Ariz., Univ. of Arizona, 1966. 145p.

Thesis.

The mean lives of the 1.74-, 2.15- and 3.58-MeV states in $^{10}B$ and the 2.31-MeV state in $^{14}N$ were measured, and limits were placed on the mean lives of the 5.10- and 3.95-MeV states in $^{14}N$ by the Doppler-shift attenuation method. The reactions $^{11}B(^3He,\alpha)^{10}B$ and $^{12}C(^3He,p)^{14}N$ were used and the direction of the recoiling nucleus was selected by a coincidence technique. The results of the measurement on $^{10}B$ are compared with predictions made from the independent particle model with intermediate coupling. The coupling parameter was found to have the values $1.5 < a/K < 3.0$. The results of the measurements on $^{14}N$ are compared with predictions made from the independent particle model with both extreme j-j coupling and L-S coupling schemes. The L-S coupling scheme was found to apply for the 2.31-MeV state and found not to apply to the 3.95-MeV state. The result of the measurement on the 5.10-MeV state is compared to predicted intensities of the three multipole radiations proposed to be present and no inconsistency with this proposal was found. The mixing ratio of E2 to M1 multipole radiations in the transition from the 2.15-MeV state to the 0.72-MeV state in $^{10}B$ was measured by an angular correlation technique. The reaction $^{11}B(^3He,\alpha)^{10}B$ was used, and the angular distribution of the $\gamma$ ray was measured in coincidence with $\alpha$ particles emitted in the beam direction. The mixing ratio was found to be $|x| \leq 0.07$. The angular distributions of $\alpha$ particles leading to the four lowest states in $^{10}B$ from the reaction $^{11}B(^3He,\alpha)^{10}B$ were measured for $^3$He energies of 1.0, 1.8, and 2.15 Mev. The distributions were compared with predictions made from the plane-wave Butler pick-up theory which was extended to the case of $(^3He,\alpha)$ reactions. The comparison indicates the presence of direct interaction mechanism for the excitation of the three lowest states in $^{10}B$. The $\alpha$ particles associated with the formation of the 2.15-MeV state in $^{10}B$ were symmetric about 90° in the center of mass system. The excitation functions for the formation of the five lowest states in $^{10}B$ by the $^{11}B(^3He,\alpha)^{10}B$ reaction were measured for $^3$He energies from 1.0 to 2.15 MeV. (Dissertation Abstr.)

**2650** SHELL-MODEL INVESTIGATION OF THE MASS-16 NUCLEI. Wong, Samuel Shaw Ming. Rochester, N. Y., Univ. of Rochester, 1966. 186p.

Thesis.

An investigation of the $2\hbar\omega$ excited states of mass-16 nuclei was carried out in the general framework of the nuclear shell model. All states that can be reached by a $2\hbar\omega$ excitation of a single particle from the doubly closed shell of 16 nucleons, or by $1\hbar\omega$ excitations of two particles, were included. Two standard central forces, the Rosenfeld and Soper exchange mixtures with Yukawa-shaped well, and a realistic Brueckner-Gammel-Thaler force were used. The general agreement of the theoretical spectrum with that observed below 15-MeV excitation in $^{16}O$ is fair; above that however, except for the two lowest isobaric-spin-2 states, there is not sufficient experimental information to allow a meaningful comparison. All three forces used give correct predictions for the energies of the two T = 2 levels observed. A striking result is that a 30% admixture of particle-hole excitations is predicted for the ground-state wave function of $^{16}O$. The $^{16}N(\beta^-)^{16}O$ branching ratios and $^{16}C(\beta^-)^{16}N$ $\log_{10}$ ft values were also calculated. The agreement with data is fair for the decay of $^{16}N$ to $^{16}O$, but because of experimental uncertainties with the $^{16}C$ decay, it is not possible to compare the predicted value with the experimental half life of $^{16}C$. In general, the electromagnetic transition rates calculated are consistent with the data except that the strong enhancements of certain E2 transition rates in $^{16}O$ are not reproduced. The investigation is the first major application of a series of computer programs written as a joint project between the University of Rochester and Oak Ridge National Laboratory for general studies of nuclear structure problems. In this program, the eigenvalues and eigenvector of a Hamiltonian, with the two-body force expressed in terms of two-body matrix elements, are automatically calculated by a linked program which also includes the generation of all multi-particle multishell wave function and the addition of the one-body energies. Included also are computer codes for the elimination of center-of-mass spurious states, the evaluation of matrix elements of one-body operators with the resultant eigenvectors and the calculation of two-body matrix elements for any central, tensor and two-body spin-orbit forces. The maximum size of matrice that can be handled by the programs is at present 150 × 150. Further extensions are being made to enable the programs to handle larger and more complex problems. (Dissertation Abstr.)

# Nuclear Properties and Reactions, $20 \leq A \leq 89$

*Refer also to abstracts 1382, 1593, 1621, 2601, 2603, 2608, 2617, 2628, 2630, 2634, 2729, 2764, 2765, 2767, 2772, 2775, 2791, 2807, 2808, and 2810.*

**2651** (AECL-2612) PHYSICS DIVISION PROGRESS REPORT, OCTOBER 1, 1965–DECEMBER 31, 1965. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). 58p. (PR-P-68). Dep. mn. AECL $1.50.

The direct $\gamma$ spectrum from the reaction $^{25}Mg(\alpha,n\gamma)^{28}Si$ was measured as a function of the $\alpha$-particle energy and the angle of the emitted $\gamma$ rays using a 25-cm$^3$ Li-drifted Ge $\gamma$ detector. From the observed $\gamma$-ray Doppler broadenings and shifts, the lifetimes of all known levels up to 7.41 MeV in $^{28}Si$ are being determined. It is found that the electric quadrupole (E2) transitions from the 4+, 4.62-MeV and 0+, 4.97-MeV levels to the 2+, 1.78-MeV level are enhanced by about a factor of six compared with the radiation from a single proton free to move throughout the nucleus, but the E2 transition from the 3+, 6.27-MeV level to the 1.78-MeV level is inhibited by a factor of about $\frac{1}{300}$. The 3-, 6.88 MeV level decays mainly by an enhanced electric octupole (E3) transition to the ground state. The evidence on the positive-parity levels of $^{28}Si$ tends to support a classification ($SU_3$) of the levels based on the amount of spatial symmetry in each level. Using the above technique with the reaction $^{26}Mg(\alpha,n\gamma)^{29}Si$, the $\gamma$ decay scheme from the 3.62-MeV level in $^{29}Si$ was also studied. No Doppler shifts in the $\gamma$ rays from this level were observed, and it is estimated that the lifetime of the 3.62-MeV level is $>3 \times 10^{-12}$ sec. This implies that the electric dipole transitions (E1) from the 3.62-MeV level to the 3.07- and 2.43-MeV levels are inhibited over single-particle estimates by factors of $<2 \times 10^{-4}$ and $<8 \times 10^{-5}$, respectively. These data are consistent with a collective model of $^{28}Si$. Using the reaction $^{27}Al(\alpha,p)^{30}Si$, Doppler shift measurements were made, giving lifetime estimates for the lowest four excited states in $^{30}Si$. A preliminary study of the electric quadrupole transition enhancements over single-particle values suggests that collective motions in this nucleus are relatively weak. The reaction $^{12}C(^{16}O,\alpha_1)^{24}Mg^*(\alpha_2)^{20}Ne$ was used to study levels in $^{24}Mg$. The $\alpha_1$ particles were detected at 0 to the $^{16}O$ beam using a magnetic spectrometer with three surface-barrier detectors mounted in the focal plane. The angular distribution of the $\alpha_2$ particles was measured with an array of eight Li-drifted Si counters which could be rotated to cover a total angular range from 25 to 165°. In some

measurements, one of the array counters was replaced by a 5 in. × 6 in. NaI(Tl) crystal in order to obtain coincidence γ spectra. The results established a 6+ level at 14.08 MeV, a 5- level at 14.14 MeV, and a probable 8+ level at a slightly higher energy in $^{24}$Mg. Using the same technique with the reaction $^{12}C(^{12}C,\alpha_1)^{20}Ne^*(\alpha_2)^{16}O$, further work was carried out on $^{20}$Ne. A level at 11.99 MeV was identified as 8+ and is believed to be the fifth and last member of the ground-state band in $^{20}$Ne. An experiment was carried out to measure the absolute yield of neutrons from thick targets of Be, Sn, Pb, and $^{238}$U bombarded by high-energy protons. A further experiment was carried out using a 900-MeV proton beam to measure the neutron energies and angular distribution. The target was an 8 in. × 12 in. long cylinder of lead, and neutrons emerging from the target at various angles were analyzed in a time-of-flight spectrometer. The observed neutron spectra consisted of two components: a low-energy component (below 20 MeV) which was isotropic and a high-energy component (measured up to 200 MeV) mainly in a broad cone about the initial direction of the protons. The high-energy component is the expected cascade component arising from knock on nucleon-nucleon collisions, and the isotropic component is interpreted as due to neutron evaporation from the nuclei which are left highly excited by the high energy collisions. Uranium dioxide is antiferromagnetic below 28°K; the magnetic excitations of the ordered spin structure were studied at 9°K using inelastic neutron scattering techniques. The measurements were made using the triple-axis crystal spectrometer at the C5 facility of NRU, and excitations propagating in several crystal symmetry directions were studied. The experiments show that there is a strong interaction between the magnetic excitations and certain transverse acoustic phonons. Theoretical work is in progress in an attempt to deduce the magnon-phonon coupling constant in uranium dioxide. The frequency of the normal modes of vibration in the (1$\bar{1}$0) plane of potassium iodide at 92°K were determined by inelastic neutron scattering techniques. Two instruments were employed in these experiments: the phased-rotor time-of-flight machine at facility E2 of NRU and the triple-axis crystal spectrometer at C5 of NRU. With the phased-rotor instrument about 140 hf phonons propagating in non-symmetry directions were measured. With the triple-axis spectrometer a detailed study of the phonons propagating along three high-symmetry directions was made. Interatomic force models similar to those used earlier for K Br and Na I were successfully fitted to the high-symmetry data, together with the refractive index and elastic constants of K I. The best-fitted model was then used to compute the frequencies of other normal modes. Good agreement between the calculated and observed values was obtained even for the non-symmetry direction modes. Analogous data for NaF were recorded at Harwell, and calculations carried out here have now successfully fitted these data with a similar interatomic force model. (auth)

**2652** (ANL-7198) PHYSICS DIVISION SUMMARY REPORT, MARCH–APRIL 1966. (Argonne National Lab., Ill.). Contract W-31-109-eng-38. 71p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The electron-neutron interaction was investigated, as a measure of the electric structure factor of the neutron, using thermal-neutron scattering by Ar, Kr, and Xe. The parity of the 5.00-MeV level of $^{12}$B was established using the CDC-3600 computer on-line with a neutron scattering experiment on $^{11}$B at the Van de Graaff accelerator; normal computer operation was interrupted and resumed automatically to analyze the data. Gamma coincidence measurements with Li-drifted Ge detectors were investigated; gamma spectra from thermal-neutron capture by $^{71}$Ga and following beta decay of $^{66}$Ga were measured. A decay scheme of $^{66}$Ga was proposed. The measurement of level lifetimes using the gamma Doppler shift was also studied; a surprisingly long E2 lifetime was measured for the third excited state of $^{41}$Ca. (D.C.W.)

**2653** (BNL-325(2nd Ed.)(Suppl.2)(Vol.2A)) NEUTRON CROSS SECTIONS. VOLUME IIA. Z = 21 TO 40. Goldberg, Murrey D.; Mughabghab, Said F.; Magurno, Benjamin A.; May, Victoria M. (Brookhaven National Lab., Upton, N. Y.). Feb. 1966. Contract AT(30-2)-Gen-16. 393p. Dep. mn. CFSTI $4.00 cy, $1.75 mn.

An updated compilation of thermal cross sections, resonance parameters, and cross-section curves is presented for elements and isotopes with Z = 21 to 40. The reference sources are also included. (D.C.W.)

**2654** (CEA-R-2925) ETUDE DES PHENOMENES DE DISPERSION LIES A L'ABSORPTION DE FLUORESCENCE RESONNANTE SANS RECUL DES NOYAUX ATOMIQUES. (Dispersion Phenomena Connected with the Absorption by Recoilless Nuclear Resonance Fluorescence). Imbert, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1966. 78p. Dep. mn.

Thesis. Submitted to Univ., Paris.

In nuclear resonance fluorescence as in the optical field abnormal dispersion curves are related to the absorption lines. It is possible, by using quadrupolar or magnetic splitting of the line in the case of recoilless resonance fluorescence (Mössbauer effect) to obtain differential dispersion effects between the two orthogonal linear or the two inverse circular components of the incident gamma radiation. These effects induce birefraction phenomena or Faraday rotation on the gamma beam, which have been studied on $^{57}$Fe enriched absorbers. (auth)

**2655** (NP-16333) ALPHA-CAPTURE REACTIONS IN $^{20}$Ne, $^{24}$Mg, AND $^{28}$Si. Smulders, Petrus Joseph Maria (Utrecht Rijksuniversiteit (Netherlands)). 1965. 62p. Dep. mn.

Thesis.

The energy levels of $^{24}$Mg, $^{28}$Si, and $^{32}$S were investigated using the $(\alpha,\gamma)$ reaction on $^{20}$Ne, $^{24}$Mg, and $^{28}$Si at alpha energies between 1.2 and 3.3 MeV. The results for the last two reactions were compared with the results of studies of the reactions $^{27}Al(p,\gamma)^{28}Si$ and $^{31}P(p,\gamma)^{32}S$. (D.C.W.)

**2656** RECOIL RANGES OF PRODUCTS FROM REACTIONS OF $^{65}$Cu WITH 11- TO 33-MeV $^{3}$He IONS. Saha, G. B.; Porile, N. T. (Purdue Univ., Lafayette, Ind.). Phys. Rev., 151: 907-9 (Nov. 18, 1966). (COO-1505-11).

Average projected ranges were determined for the $(^3He,n)$, $(^3He,2n)$, and $(^3He,\alpha)$ reactions of $^{65}$Cu over the energy range of 11 to 35 MeV. The results were compared with calculations based on the assumption of compound-nucleus formation. Excellent agreement is obtained for the $(^3He,2n)$ reaction at all energies and for the $(^3He,n)$ reaction up to 17 MeV. The ranges of $^{64}$Cu are much smaller than the theoretical values at all energies, indicating that the $(^3He,\alpha)$ reaction involves a direct interaction. (auth)

**2657** GAMMA RAYS FROM $^{66}$Ga. Freedman, Melvin S.; Porter, Fred T.; Wagner, Frank (Argonne National Lab., Ill.). Phys. Rev., 151: 899-906(Nov. 18, 1966).

Twenty-four gamma rays up to 4.8-MeV energy in the decay of 9.5-hr $^{66}$Ga were measured to an accuracy of 1.5 keV with a lithium-drifted germanium detector and were assigned to a level scheme in close agreement with that of Schwarzschild and Grodzins. Prominent gamma rays, useful in Ge(Li) calibration are: 4.8059, 4.4616, 4.2950, 4.0862, 3.7915, 3.3812, 3.2294, 2.7524, and 2.4231 MeV. The four highest energy values are 0.7 to 2.3 keV lower than the values of Coté. (auth)

**2658** INTERNAL CONVERSION, MULTIPOLE MIXING, AND AUGER SPECTRUM IN $^{67}$Zn FROM $^{67}$Ga DECAY. Freedman, Melvin S.; Porter, Fred T.; Wagner, Frank (Argonne National Lab., Ill.). Phys. Rev., 151: 886-98(Nov. 18, 1966).

Absolute internal-conversion coefficients measured with high electron resolution and with a Ge(Li) spectrometer were studied in seven transitions in $^{67}$Zn from 78-hr $^{67}$Ga decay. From these and from L subshell ratios for the three lowest energy transitions, the following multipolarities were obtained: 93 kev, pure E2; 184 kev, M1 + (8–12% E2); all others predominantly M1, and E2 required in the 91- and 494-kev transitions. The retardation factor of the l-allowed 91-kev transition is 500, which is larger than that (340) for the l-forbidden 184-kev transition (E2-component enhancement of 17) originating at the same level. Conversion data, together with a reanalysis of γ–γ angular-correlation measurements of Rietjens and Van den Bold, lead unambiguously to the following level spin assignments, in agreement with those from (d,p) stripping and Coulomb excitation: (keV, $J_\pi$); ground state $\frac{1}{2}-$; 93.317 ± 0.02; $\frac{1}{2}-$; 184.595 ± 0.04, $\frac{3}{2}-$; 393.59 ± 0.04, $\frac{3}{2}-$; 887.87 ± 0.1, $\frac{3}{2}-$. Conversion coefficients show somewhat better agreement with those calculated by Sliv and Band (extrapolated from Z = 33) than with those of Rose for the L shell, but indicate that both computations give L-shell coefficients too small (~10% for Sliv and Band, ~20% for Rose) for this Z range. The empirical Z displacement rule for $M_1$ conversion due to Chu and Perlman ($\Delta Z = -7.0$), which, applied to the unscreened, point-nucleus M conversion values of Rose gives agreement for all energies and multipolarities above Z = 50, is found to require $\Delta Z = -9.5$ for agreement at Z = 30. Six of nine predicted lines in the KLL Auger spectrum of Zn are resolved; energies determined are 7–13 ev above those calculated by Hörnfeldt, and intensities agree with recent experimental results at Z = 32 except for the $K-L_1L_3$ ($^3P_1$) line, where the intensity is lower by a factor of 2. (auth)

**2659** CROSS SECTIONS OF $^{35,37}$Cl(n,n′γ) REACTIONS. Nichols, Davis B.; Kern, B. D.; McEllistrem, M. T. (Univ. of Kentucky, Lexington). Phys. Rev., 151: 879-86(Nov. 18, 1966).

Production cross sections for the (n,n′γ) reactions on $^{35}$Cl and $^{37}$Cl were measured at incident neutron energies of 2.54, 3.09, and 4.03 Mev. Angular distributions of the gamma rays were measured at 3.05 and 4.23 Mev. Gamma rays were detected with NaI(Tl) and Ge(Li) detectors using pulsed-beam techniques to eliminate backgrounds. Cylindrical and spherical samples of $CCl_4$ and $C_2Cl_6$ were used as well as $^{37}$Cl-enriched NaCl samples. Interpretation of the

angular distributions and production cross sections permitted spin assignments of $\frac{1}{2}$, $\frac{5}{2}$, and $\frac{7}{2}$ to the first three excited levels of $^{35}$Cl, and $\frac{1}{2}$ and $\frac{5}{2}$ to the first and fourth excited levels of $^{37}$Cl. Excitation energies of 1.726 ± 0.004 and 3.71 ± 0.02 Mev were measured for these two levels of $^{37}$Cl. (auth)

**2660** (p,n) REACTIONS ON $^{88}$Sr and $^{89}$Y AND THE REACTION MECHANISM VIA ISOBARIC SPIN ANALOGUE RESONANCES. Kim, H. J.; Robinson, R. L. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Phys. Rev., 151: 920-6(Nov. 18, 1966). (ORNL-P-2342).

Differential cross sections for the reactions $^{88}$Sr(p,n)$^{88}$Y (ground state), $^{89}$Y(p,n)$^{89}$Zr (ground state), and $^{89}$Y(p,n)$^{89}$Zr* (590-keV state) are investigated in the vicinity ($E_p \approx 5$ MeV) of $d_{\frac{5}{2}}$ isobaric analogue states in the compound nuclei $^{89}$Y and $^{90}$Zr. Angular distributions and forward angle excitation functions of the neutrons from these reactions are investigated by a time-of-flight method in conjunction with a pulsed proton beam. The observed energy dependence and the angular dependence of the neutrons are analyzed in terms of mixing of the isobaric analogue state with the background states of the compound nucleus. The experimental results can be explained by the two-channel R-matrix theory of the isobaric analogue resonance and the statistical compound-nuclear reaction theory. (auth)

**2661** TOTAL CROSS SECTIONS FOR KILOVOLT NEUTRONS OF EVEN-ODD NUCLEI IN THE REGION OF THE 3s STRENGTH-FUNCTION RESONANCES. Good, W. M.; Paya, D.; Wagner, R.; Tamura, T. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Phys. Rev., 151: 912-19(Nov. 18, 1966). (ORNL-P-2082).

The 3s strength-function resonance has its maximum value in nuclei for which the major 28-neutron shell is near closure or just beyond. In view of this fact, it seemed desirable to investigate this mass region more extensively, and the even-even compound nuclei which lie in the region of the 3s strength-function resonance were studied. It was found that the resonances in $^{53}$Cr and, to a certain extent, in $^{57}$Fe show an uncommon tendency to cluster. The result is that for $^{53}$Cr the strength function below 10 keV has a relatively large value of about $12 \times 10^{-4}$, whereas in the energy interval 3 to 60 keV the value is about $5 \times 10^{-4}$, in accord with the optical-model prediction. This situation suggests that the relatively large peak values of about $10 \times 10^{-4}$ which certain experiments show for the 3s strength-function resonance may result from a tendency for several nuclides in the vicinity of $^{53}$Cr to have rather large "local" strengths in a manner similar to that of $^{53}$Cr. This means that the maximum value of the 3s strength function is actually about $4.5 \times 10^{-4}$. A quasiparticle calculation is made to try to understand the spacings observed. Excepting $^{53}$Cr, the calculations showed good agreement with experiment, in that the observed levels are predominantly of the four-quasiparticle type, since two-quasiparticle types are relatively so few in number that they are not likely to be seen. (auth)

**2662** (t,$^4$He) REACTION ON THE EVEN Ni ISOTOPES. Blair, A. G.; Armstrong, D. D. (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-Eng-36. Phys. Rev., 151: 930-9 (Nov. 18, 1966). (LA-DC-7722).

A beam of 15-MeV tritons was used to bombard thin targets of $^{58}$Ni, $^{60}$Ni, $^{62}$Ni, and $^{64}$Ni. States up to several MeV of excitation in $^{57}$Co, $^{59}$Co, $^{61}$Co, and $^{63}$Co were observed by means of the (t,$^4$He) reaction. Spin and parity assignments were made by comparing the experimental angular distributions with distributions from states whose assignments are known, by comparing them with the predictions of a distorted-wave calculation, and from shell-model considerations. In the reaction to each of the four Co nuclides, several $f_{\frac{7}{2}}$ transitions were observed in addition to the strong $f_{\frac{7}{2}}$ ground-state transition including one to three relatively weak $p_{\frac{3}{2}}$ transitions and two strong transitions representing the major fragments of the $(2s_{\frac{1}{2}})^{-1}$ and $(1d_{\frac{5}{2}})^{-1}$ shell-model states. The $s_{\frac{1}{2}}$ transition occurs at a lower excitation energy than the $d_{\frac{5}{2}}$ transition, an ordering which is the inverse of that previously observed in the (d,$^3$He) reaction on Ti nuclides. There is no evidence that the strong Q dependence of angular distributions previously observed in the ($^4$He,t) reaction occurs in the (t,$^4$He) reaction. The distorted-wave calculation comparison suggests that refinements in the calculation are needed. (auth)

**2663** ($^3$He,$\alpha$) PICKUP REACTION IN $^{32}$S. Fou, C. M.; Zurmuehle, R. W. (Univ. of Pennsylvania, Philadelphia). Phys. Rev., 151: 927-9(Nov. 18, 1966).

The ($^3$He,$\alpha$) pickup reaction was studied in $^{32}$S with a 15-MeV $^3$He beam from the University of Pennsylvania tandem accelerator. Angular distributions of the strongly excited low-lying states in $^{31}$S were measured. Distorted-wave Born approximation analysis was performed to give l-value assignments and to extract spectroscopic factors. J dependence of the l = 2 angular distributions was observed. (auth)

**2664** INELASTIC SCATTERING OF PROTONS BY $^{21}$Ne AND SPIN AND PARITY OF THE FIRST EXCITED STATE OF $^{21}$Ne. Storizhko, V. E.; Ekhichev, O. I.; Popov, A. I.; Slabospitskii, R. P. (Physicotechnical Inst., Academy of Sciences, Ukrainian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 249-54(Feb. 1966). (In Russian).

The inelastic scattering of 1- to 3-MeV protons on $^{21}$Ne was investigated in order to obtain information concerning the excited states of the $^{22}$Na compound nucleus and to determine the spin and parity of the 350-keV first excited state of $^{21}$Ne. An enriched (30% $^{21}$Ne and 70% $^{20}$Ne and $^{22}$Ne) target of neon embedded in a 0.1 mm thick tantalum substrate was employed. The 90° yield of 350-keV gamma rays was determined as a function of incident proton energy. Some 60 resonances were observed; and the energies, widths, and relative intensities of 24 of them are tabulated. The resonances at proton energies below 2.3 MeV were mostly well separated, and their energies were determined with an accuracy of 5 keV. The resonances at higher proton energies were not well separated and they were not investigated further. Angular distributions of the 350-keV gamma rays associated with the different resonances were measured, and the coefficients $A_2$ and $A_4$ in the expression $1 + A_2P_2(\cos\Theta) + A_4P_4(\cos\Theta)$ for the angular distribution are tabulated for 19 of the resonances. For all but 7 of the resonances, the value obtained for $A_4$ was less than its probable error, and for only one of the resonances did $A_4$ exceed its probable error by as much as a factor 2. From that it is concluded that the spin of the 350-keV level does not exceed $\frac{5}{2}$. Theoretical angular distributions were calculated with different assumptions concerning the spin and parity of the 350-keV $^{21}$Ne level and the characteristics of the $^{22}$Na states. It is concluded that the spin and parity of the 350-keV $^{21}$Ne level are $\frac{5}{2}^+$. (ATD)

**2665** EXCITATION OF ISOBARIC ANALOG STATES IN $^{59}$Cu, $^{61}$Cu, $^{62}$Cu, $^{63}$Cu, AND $^{65}$Cu. Borkin, I. M.; Guzhovskii, B. Ya.; Rudnev, B. S.; Solodovnikov, A. P.; Trusillo, S. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 271-7(Feb. 1966). (In Russian).

Excitation functions of the $^A$Ni(p,n)$^A$Cu reactions for A = 60, 61, 62, and 64, and inelastic proton scattering cross sections of $^A$Ni for A = 58, 60, 62, and 64 were measured at incident proton energies up to 8 MeV in order to determine the $^A$Ni−$^A$Cu Coulomb energy differences. Targets of 0.2 mg/cm$^2$ of Ni on an Au substrate were employed for the (p,n) measurements for proton energies up to 6.2 MeV, and 2 mg/cm$^2$ Ni foils were used for the inelastic scattering measurements and for the (p,n) measurements at energies above 6.2 MeV. In the (p,n) measurements the neutron yield was determined at 0 and 90°, and the inelastic proton scattering cross sections were measured (in arbitrary units) at 90 and 160°. Resonances corresponding to excitation of analogous states were identified with the aid of the approximate value 9.45 MeV for the Ni−Cu Coulomb energy difference. For each mass number the Coulomb energy difference was determined from measurements of some ten resonances. The $^A$Ni−$^A$Cu Coulomb energy difference was found to be practically constant and equal to 9.226 MeV for A = 61, 63, and 65 and to be about 90 keV higher for A = 59 and 62. The 90-keV difference is much higher than the experimental errors, which are estimated at from 17 to 25 keV, and it is also higher than the 40 keV which is the maximum that could be ascribed to shell effects. (ATD)

**2666** ENERGY SPECTRA OF THE FINAL NUCLEI IN (p,2p) REACTIONS ON DEFORMED 1d-2s SHELL NUCLEI. Zelenskaya, N. S.; Smirnov, Yu. F. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 285-91(Feb. 1966). (In Russian).

Previous unified-model calculations of quasi-elastic proton and deuteron knockout reactions on deformed 1d-2s shell nuclei were extended to take into account the effect of rotational band mixing i.e., of the coupling between the single-particle and rotational motions. The calculations were motivated by the appearance of the experimental excitation curves for the (p,2p) reactions on $^{24}$Mg, $^{27}$Al, $^{28}$Si, and $^{31}$P, which disagreed with the previous calculations in such a way as to suggest that rotational band mixing might be significant. The calculations of Kerman of the effect of Coriolis forces on the rotational level energies and the nuclear wave functions are empolyed to calculate the changes in the spectroscopic factors in the reduced widths, and these are used to correct the earlier calculations of the excitation functions for the (p,2p) reactions on $^{24}$Mg, $^{27}$Al, $^{28}$Si, and $^{31}$P. Rather good agreement with experiment is achieved. The peculiar features of each of the reactions are discussed. It is concluded that the strong coupling scheme in its pure form can not account for the features of (p,2p) reactions on deformed 1d-2s shell nuclei, but that rotation band mixing must be taken into account. In the case of slightly deformed 1d-2s shell nuclei, rotation band mixing due to Coriolis forces not

only shifts the nuclear levels but also alters the probabilities for their excitation in (p,2p) reactions. By taking rotation band mixing into account, good agreement with the experimental data can be achieved. It is suggested that experimental data on the (p,2p) reactions on the lightest 1d-2s shell nuclei (not heavier than $^{20}$Ne) as well as an analysis of the levels of those nuclei on the basis of the $SU_3$ scheme of Elliott would be desirable. (ATD)

**2667** INVESTIGATION WITH THE AID OF A Ge(Li) SEMICONDUCTOR DETECTOR OF THE SOFT GAMMA RADIATION OF THE ODD-ODD NUCLEI $^{46}$Sc, $^{56}$Mn, $^{60}$Co, $^{76}$As, $^{108}$Ag, $^{110}$Ag, $^{116}$In, AND $^{134}$Cs PRODUCED IN NEUTRON-CAPTURE REACTIONS. Berestovoi, A. M.; Kondurov, I. A.; Loginov, Yu. E. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 359-66(Feb. 1966). (In Russian).

The low-energy (50 to 700 keV) $\gamma$ spectra of $^{46}$Sc, $^{56}$Mn, $^{60}$Co, $^{76}$As, $^{108}$Ag, $^{110}$Ag, $^{116}$In, and $^{134}$Cs produced in (n,$\gamma$) reactions a 15-mm-diameter, 1-mm-thick lithium-drifted germanium detector. The detector was mounted near the bottom of a Dewar flask containing liquid nitrogen and was shielded on the sides with a large block of lead. The detector was shielded from the target mounted below the Dewar with 5 mm of lead. The target was irradiated with thermal neutrons filtered through 10 cm of lead in a reactor and further moderated with 25 cm of quartz. Energy calibration was effected with the aid of monochromatic $\gamma$ rays from $^{123m}$Te and $^{137}$Cs, and with $\gamma$ rays from $^{181}$Hf. The spectra were recorded with a 256-channel, pulse-height analyzer. The eight spectra are presented graphically, compared with the findings of other investigators, and discussed. In many cases improved energy evaluations were obtained, due to the high energy resolution of the semiconductor detector as compared with the scintillators frequently employed for soft $\gamma$ measurements. Two previously unreported lines (at 159 and 257 keV) were found in the $^{60}$Co spectrum, and a number of previously unreported lines were found in the $^{134}$Cs spectrum. The $^{76}$As spectrum was not in agreement with some previous observations. (ATD)

**2668** GAMMA-RAY ABSORPTION CROSS SECTIONS OF $^{19}$F, $^{24}$Mg, AND $^{40}$Ca IN THE 10- TO 30-MeV ENERGY REGION. Dolbilkin, B. S.; Zapevalov, V. A.; Korin, V. A.; Lazareva, L. E.; Nikolaev, F. A. (Lebedev Inst. of Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 349-58(Feb. 1966). (In Russian).

An electron-positron pair type $\gamma$ spectrometer with an energy resolution of 220 keV at 20 MeV was used to measure the absorption cross sections of $^{19}$F, $^{24}$Mg, and $^{40}$Ca for 10- to 30-MeV $\gamma$ rays in the bremsstrahlung beam from a 260-MeV synchrotron. As absorbers there were employed a 138.6 g/cm$^2$ block of commercial teflon (the absorption due to carbon was eliminated with the aid of measurements with a 33.3 g/cm$^2$ graphite absorber), a 112.4 g/cm$^2$ block of 99.9% pure metallic magnesium, and a 70.84 g/cm$^2$ block of 99% pure metallic calcium, kept in an oil bath. The measured absorption cross sections were corrected for non-nuclear absorption due to pair production and the Compton effect. The nuclear absorption cross sections are presented graphically, are compared with the data and calculations, and are discussed at length. The $\gamma$ absorption cross sections of $^{19}$F, $^{24}$Mg, and $^{40}$Ca, integrated over the investigated energy range, were 335, 365, and 930 mb MeV, respectively. The integrated cross sections of $^{19}$F and $^{40}$Ca agree, within the experimental error, with the values given by the dipole sum rule; but the measured integrated cross section of $^{24}$Mg is only 72% of the sum rule value, although there are theoretical calculations indicating that substantially all the dipole transitions in $^{24}$Mg should lie below 30 MeV. (ATD)

**2669** STRIPPING ANALYSIS OF THE $^{45}$Sc(d,p)$^{46}$Sc REACTION. Rapaport, J.; Sperduto, A.; Buechner, W. W. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 151: 939-49(Nov. 18, 1966). (MIT-2098-240)

The $^{45}$Sc(d,p)$^{46}$Sc reaction was studied with a multiple-gap magnetic spectrograph. Eighty-four energy levels were observed, and angular distributions of the corresponding proton groups were analyzed up to an excitation energy of 4.0 MeV. Eighty-five additional energy levels in $^{46}$Sc were observed between 4.0 and 6.0 MeV where the level density is seen to increase rapidly with excitation energy. Some unresolved particle groups are estimated to have separations of a few keV. The ground-state Q value was measured to be 6.541 ± 0.008 MeV. The angular distributions were measured in 7.5° intervals between 7.5 and 172.5°. The assignments of the captured-neutron angular-momentum $l_n$ were based on the position of the first maximum as predicted by a distorted-wave Born-approximation theoretical calculation. The transition strengths for the groups, for which $l_n$ assignments were made, were determined from the measured differential cross sections and the predictions of the distorted-wave, deuteron-stripping analysis. (auth)

**2670** PHOTOPROTONS FROM MAGNESIUM. Ishkhanov, B. S.; Kapitonov, I. M.; Shevchenko, V. G.; Yur'ev, B. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 378-82(Feb. 1966). (In Russian).

The energy and angular distributions of protons ejected from a 9.2 mg/cm$^2$ target of 99.9% pure magnesium of the natural isotopic composition by 23- and 34-MeV bremsstrahlung from a 35-MeV betatron were measured and the total $^{24}$Mg ($\gamma$,p) cross section was measured as a function of $\gamma$ energy in order to obtain data for comparison with theory on the giant dipole resonance in nuclei between $^{12}$C and $^{16}$O, for which particle-hole calculations based on the shell model are known to give a satisfactory description of the photodisintegration process, and $^{40}$Ca, for which similar calculations fail to account for a number of features of the process. The energy and angular distributions of the photoprotons were determined with 400-micron-thick nuclear emulsions. The total cross section as a function of $\gamma$ energy was calculated by the method of Penfold and Leiss from yield curves measured with scintillation spectrometers, using a 12.2-mg/cm$^2$ target. The angular distributions of the photoprotons with energies below 6.7 MeV were practically isotropic, indicating the participation in the photodisintegration process of a number of levels with different orbital angular momenta. The integrated ($\gamma$,p) cross section was 180 mb-MeV; when that is added to the integrated ($\gamma$,n) cross section, the sum is 265 mb-MeV, which may be compared with the value of 360 mb-MeV given by the dipole sum rule. (ATD)

**2671** (n,2n) EFFECTIVE CROSS SECTIONS FOR NUCLIDES WITH NEUTRON NUMBERS NEAR THE MAGIC NUMBER 50 AT $E_n \sim 14$ Mev. Rieder, R.; Muenzer, H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 42-3(1966). (In German).

A study was made to determine whether, after elimination of the effects on the magnitude of the (n,2n) cross section given by the shell-dependent neutron binding energies, an additional shell effect can be observed. The (n,2n) cross sections were measured on a series of elements with neutron numbers of 48, 50, and 52 using the activation method. The nuclides studied were $^{85}$Rb, $^{86}$Sr, $^{87}$Rb, $^{89}$Y, $^{90}$Zr, $^{93}$Nb, and $^{96}$Ru. The results are tabulated and show no effect of the closed shell N = 50. (J.S.R.)

**2672** MEASUREMENT OF EFFECTIVE CROSS SECTIONS OF THE (n,t) REACTION ON $^{32}$S AND ON $^{40}$Ca FOR 14.8-Mev NEUTRONS. Sacher, R.; Warhanek, H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 181-4 (1966). (In German).

The effective cross sections of the (n,t) reaction of $^{32}$S and $^{40}$Ca were measured by the activation method using 14.8-MeV neutrons. The $^{30}$P activity resulting from the $^{33}$S(n,t) reaction was found. A cross section for the reaction of $\sigma < 10\mu$b was found. The cross section of the $^{40}$Ca(n,t)$^{38}$K reaction was $\sigma < 15\mu$b. (J.S.R.)

**2673** (n,2n) REACTION ON LIGHT AND INTERMEDIATE NUCLEI. Breunlich, W.; Hille, P.; Karlik, B.; Tagesen, S. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 37-41(1966). (In German).

The theoretical values of the (n,2n) cross section calculated under the assumption that a second neutron is always emitted when it is energetically possible were compared with the experimental values. The results show that the theoretical and experimental values agree well for heavy nuclei of A > 100 but in light nuclei there are considerable discrepancies. The origin of the discrepancies is discussed. The ratio of $\sigma_{exp}/\sigma_{theor}$ was plotted against N − Z and (N − Z)/A, and the corrections from these two curves were applied to the $^{58}$Ni(n,2n)$^{57}$Ni reaction. (J.S.R.)

**2674** COMPETING GAMMA EMISSION WITH THE (n,2n) REACTION ON $^{52}$Cr. Tagesen, Siegfried; Hille, P. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 31-6(1966). (In German).

In order to determine the reason for the wide variation between the experimental and theoretical values for the (n,2n) cross section, an absolute determination was made of the neutron inelastic scattering cross section of $^{52}$Cr using an intensity measurement of the 1.43-MeV $\gamma$ line. The cross section (n,n'$\gamma$) was measured, and a value of 740 ± 180 mb was found. This value agrees within the limits of error with an estimation made on the cross section of the (n,n'$\gamma$) reaction for $^{52}$Cr. These results lead to the conclusion that the simplifying assumption that neutron emission always occurs when it is energetically possible leads to the error in the case of $^{52}$Cr since the measurement value gives the ratio of $\sigma$(n,n' + n'') to $\sigma$(n,n' + $\gamma$) = 1 to 2.7 instead of 1.5 to 1 as would be expected if the assumptions were correct. (J.S.R.)

**2675** REACTION CROSS SECTIONS FOR $^{76}$Se(n,2n)$^{75}$Se, $^{74}$Se(n,p)$^{74}$As, AND $^{75}$As(n,2n)$^{74}$As(n,2n)$^{74}$As AT $E_n \sim 14$ Mev. Hille, P.; Muenzer, H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 44-6(1966). (In German).

The cross section of the $^{76}$Se(n,2n)$^{75}$Se reaction at neutron energies of 14 MeV was measured. Since the irradiation of Se with 14-MeV neutrons produces a relatively strong $^{74}$As activity from

the reaction $^{74}Se(n,p)$, the $^{74}As$ activity was measured by separate production of this isotope by the reaction $^{75}As(n,2n)^{74}As$. Therefore, the $^{75}Se$ spectrum could be corrected for the perturbation by the $^{74}As$ spectrum. The cross sections obtained are tabulated and compared with results from the literature. The results on the $^{75}As(n,2n)^{74}As$ reaction agree within the limits of error with earlier values. (J.S.R.)

**2676** THE $^{26}Mg(d,n)^{27}Al$ REACTION. Lawergren, B. (Atomic Energy Research Establishment, Harwell, Eng.). Nucl. Phys., 6701A: 311-20(1967).

The neutron time-of-flight technique was used to resolve most of the known levels below 6-MeV excitation in $^{27}Al$. The angular distributions of neutron groups to levels below 3.7 MeV show typical stripping patterns which imply l-values in accord with previous $J^\pi$ assignments; in particular, $J^\pi = 3/2^+$ and $1/2^+$ for the 2.97- and 3.68-MeV states, respectively. The spectroscopic factors for levels up to 3-MeV excitation resemble, within experimental uncertainties, the predictions of both the strong- and weak-coupling models but refute the "center-of-gravity" model. The 3.68-MeV level is anomalously weakly populated, however. Among levels above 3.7-MeV excitation, only those at 5.75 and the 6.83 MeV show unambiguous stripping patterns (l = 0). The latter state is the lowest $T = 3/2$ analogue to $^{27}Mg$. (auth)

**2677** CHARACTERISTIC LYMAN-$\alpha$ EMISSION FROM PROTONS NEUTRALIZED IN A SOLID. Sterk, A. A.; Marks, C. L.; Saylor, W. P. (American Machine and Foundry Co., Alexandria, Va.). Phys. Rev. Lett., 17: 1037-9(Nov. 14, 1966).

Dunn, Geballe, and Pretzer (Phys. Rev., 128: 2200(1962)) measured the number of Lyman-$\alpha$ photons (1216 Å) produced by the impact of 2.5-keV protons on a tungsten target. The monochromaticity of the emitted photons was demonstrated by using an oxygen gas filter which had a 5-Å bandwidth transmission window at 1216 Å. Measurements taken with and without the oxygen filter produced no change in the measured uv photon intensity. The results of an experiment which verify these phenomena are presented and results of a further experiment designed to determine the origin of the emitted photons are reported. (W.D.M.)

**2678** INVESTIGATION OF INTERNAL BREMSSTRAHLUNG ACCOMPANYING BETA DECAY OF $^{32}P$ WITH A THREE-CRYSTAL SCINTILLATION SPECTROMETER. Korotkov, K. A.; Kryshkin, V. I. (Voronezh State Univ., USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2247-9(Dec. 1965). (In Russian).

The investigation of the internal bremsstrahlung from $^{32}P$ was continued. A two-crystal scintillation Compton spectrometer was employed to detect and measure the energy of the internal bremsstrahlung; only triple coincidences between the Compton electron, the Compton scattered photon, the beta particle were recorded. The beta channel employed a 7-mm-thick tolan scintillator which was so mounted as to record beta particles emitted at right angles to the direction of the internal bremsstrahlung photon. The spectrometer was calibrated twice daily with gamma rays from the aid of $^{60}Co$ and $^{95}Zr + ^{95}Nb$ sources, and it remained stable within 1% during the measurements. The $^{32}P$ source was prepared by evaporating a $Na_2HPO_4$ solution in a 2.5-mm-diameter, 3-mm-high Plexiglas cylinder with 0.5-mm wall thickness and was mounted between the two scintillators of the Compton spectrometer at a distance of 2 cm from one scintillator and 6.5 cm from the other. The tolane crystal for detecting beta particles was located 4 cm from the source. The intensity of the source was $1.17 \times 10^6$ decays/sec; it was shielded on two sides with 1.025 g/cm$^2$ disks of beryllium to avoid accidental coincidences due to beta particles. The accidental coincidence rates were determined by introducing delay lines into different inputs to the coincidence circuit and correction was made for them. The internal bremsstrahlung spectrum was recorded over the photon energy range from 300 to 1600 keV. At photon energies below 900 keV, the measurements are in good agreement with the theory of Knipp and Uhlenbeck (Physica, 3: 425(1936)) as corrected for the Coulomb effect by Lewis and Ford (Phys. Rev., 107: 756(1957)) and Nilsson (Arkiv Fysik., 10: 467(1956)). At higher energies the measured internal bremsstrahlung intensity is considerably greater than the theoretical intensity. The results are in good agreement with those of Persson (Nucl. Phys., 55: 49(1964)) over the energy range (to 1200 keV) to which the latter extend. (ATD)

**2679** INVESTIGATION OF INTERNAL BREMSSTRAHLUNG ACCOMPANYING BETA DECAY OF $^{32}P$ WITH A TWO-CRYSTAL SCINTILLATION SPECTROMETER EMPLOYING PULSE ADDITION. Korotkov, K. A.; Shumeiko, A. P. (Voronezh State Univ., USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2243-6(Dec. 1965). (In Russian).

The internal bremsstrahlung spectrum of $^{32}P$ was recorded from 300 to 1440 keV using a scintillation spectrometer with pulse addition. Corrections were introduced for decay of the source, the energy resolution of the spectrometer, the gamma recording efficiency, the residual continuous distribution accompanying the total absorption line, external bremsstrahlung in the Be absorbers, and miscounting. The results were compared with theoretical predictions. The total energy of the internal bremsstrahlung was determined. (D.C.W.)

**2680** PHOTOPROTONS FROM SULFUR. Ishkhanov, B. S.; Kapitonov, I. M.; Shevchenko, V. G.; Yurev, B. A. (Moscow State Univ.). Yadern. Fiz., 4: 765-9(Oct. 1966). (In Russian).

The angular and energy distributions of photoprotons produced in the reaction $^{32}S(\gamma,p)$ ($E_{\gamma max}$ = 22, 25, and 35 MeV) were measured using the photoplate method. The cross section of the reaction from the threshold to 31 MeV was measured using scintillation spectrometers. A conclusion is drawn on the character of the $\gamma$-quantum absorption in the region $E_\gamma > 25$ MeV. (auth)

**2681** ELASTIC SCATTERING OF LOW-ENERGY PROTONS ON MEDIUM ATOMIC WEIGHT NUCLEI. Golovnya, V. Ya.; Klyucharev, A. P.; Shilyaev, B. A.; Shlyakhov, N. A. Yadern. Fiz., 4: 770-80(Oct. 1966). (In Russian).

The elastic scattering of protons with energies far below the barrier on $^{50}Cr$, $^{52}Cr$, $^{53}Cr$, $^{54}Cr$, $^{54}Fe$, $^{56}Fe$, $^{57}Fe$, $^{58}Fe$, $^{63}Cu$, and $^{59}Co$ isotopes was investigated. The proton elastic scattering excitation functions were measured for the angles 85 and 160° in the energy region 1.6 to 3.72 MeV, so as to take possible resonance effects into account. The angular distributions of elastically scattered protons were measured for the energies 2.60, 2.84, 3.00, 3.36, and 3.44 MeV in the region of angles 35 to 160°. The results obtained show that the influence of the nuclear surface structure on the elastic scattering differential cross sections is very significant at such low energies of the incident protons. An analysis of (p,n) reaction cross section data also reveals the specific features of the surface structure of the investigated nuclei. A correlation is observed between the values of the nuclear interaction radii, obtained in the quasiclassical approximation from the present experimental data, and the total reaction cross sections for identical nuclei, measured by other authors. (auth)

**2682** INELASTIC SCATTERING OF 6.0 TO 6.5 MeV PROTONS BY Ni ISOTOPES. Halil, Munib Adel; Romanovskii, E. A.; Spasskaya, T. I.; Galakhmatova, B. S. (Moscow State Univ.). Yadern. Fiz., 4: 781-4(Oct. 1966). (In Russian).

The excitation functions and the angular distributions in the inelastic scattering of 6.0- to 6.5-MeV protons, accompanied by the excitation of the first levels in even-even Ni isotopes, have been measured. The results are compared with the data of other authors. (auth)

**2683** ON A SPECIFIC FEATURE OF THERMAL NEUTRON CAPTURE BY NUCLEI. Groshev, L. V.; Demidov, A. M. Yadern. Fiz., 4: 785-90(Oct. 1966). (In Russian).

It is noted that very intensive $\gamma$ transitions from the capturing state, produced in the capture of thermal neutrons, to levels with a low degree of "single particality," determined from the reduced neutron widths in (d,p) reactions, exist in certain nuclei ($^{57}Fe$, $^{63}Ni$, $^{65}Zn$). On the other hand, transitions from the capturing state to levels with a high single particality are weak or not observed at all. This feature cannot be understood in terms of the simple direct neutron-capture mechanism, or from the point of view of the creation of a complex compound nucleus. It is shown that the effect can be explained if it is assumed that a nucleon pair in the core of the target nucleus is excited during the neutron capture. This assumption is related to the notions on the mechanism of neutron capture through doorway states, recently developed by Feshbach et al. A list of diagrams is given, comparing the reduced neutron level widths and matrix elements for $\gamma$ transitions from the ground state to these levels for nuclei with $25 \leq A \leq 67$. (auth)

**2684** DETERMINATION OF LEVEL DENSITIES AND THE PARAMETER $\alpha$ FROM DATA ON MEAN CAPTURE CROSS SECTIONS. Kapchigashev, S. P.; Popov, Yu. P. Yadern. Fiz., 4: 686-90(Oct. 1966). (In Russian).

Radiation capture cross sections for neutrons with energies <50 keV, averaged over many resonances, were analyzed so as to obtain the parameter $\langle\Gamma_\gamma/D\rangle$. The level densities for nuclei with $51 \leq A \leq 205$ and the parameter $\alpha$, determining the density of single-nucleon states near to the Fermi surface, were calculated using the parameter $\langle\Gamma_\gamma/D\rangle$ and the radiation widths, measured for the individual resonances. The obtained results in principle agree with data obtained from calculations of the low lying resonances. The overall dependence of a(A) is in agreement with the theoretical curve of Abdelmalik and Stavinsky. (auth)

**2685** INVESTIGATION OF INELASTIC PROTON SCATTERING WITH EXCITATION OF THE 5.15- AND 5.24-Mev LEVELS IN $^{27}Al$. Vasil'ev, S. S.; Mikhaleva, T. N.; Chuprunov, D. L.

(Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 214-16(Feb. 1966). (In Russian).

Inelastic scattering of 6.28 to 6.63 MeV protons from a 3.6-micron aluminum foil target was investigated. The scattered protons that left the $^{27}Al$ scatterer in the 5.15- or the 5.24-MeV excited state were recorded with a scintillation spectrometer. Differential cross sections for excitation of the two levels by protons of different energies are presented. The angular distributions were all symmetric about 90° in the center of mass system, but the shapes of the curves varied greatly with the incident proton energy. The angular distributions were compared with calculations based on the statistical model of Hauser and Feshback (Phys. Rev., 87: 366(1952)). The angular distributions for excitation of the 5.15-MeV level were described with three statistical theory expressions for an exit-channel spin of 2 and an orbital angular momentum change of 2, and those for excitation of the 5.24-MeV level were described with two expressions for an exit-channel spin of 2 and an orbital angular momentum change of 1. The spin and parity of the 5.15-MeV level are $\frac{3}{2}^+$ or $\frac{5}{2}^+$ and those of the 5.24-MeV level are $\frac{3}{2}^-$ or $\frac{5}{2}^-$. States of the $^{28}Si$ compound nucleus having spins of 2, 3, and 4, but not states having spins of 0 or 1, participated in the reactions. (ATD)

**2686** SEARCH FOR THE DECAY OF $^{50}V$ WITH A LOW-LEVEL GAMMA SPECTROMETER. Sonntag, Ch.; Muennich, K. O. (Univ., Heidelberg). Z. Phys., 197: 300-8(1966).

The spectrometer consists of a 4″ × 4″ NaI-crystal with a double lead shield—the inner one being of selected lead—and a guard anticoincidence ring in between. The apparatus is situated in a cellar covered by 3 meters of soil. The total background above 0.03 MeV is 120 cpm, being extremely stable with an intrinsic rms variation below ±2 per mil. The crystal is surrounded by a sample container of volume 1.8 liters. An energy dependent gamma detection limit ($2\sigma$) ranging between 0.3 and 0.8 dpm has been obtained. This corresponds to a maximum detectable half life of $1.0 \times 2.7 \times 10^{18}$ years per mole of the radioactive nuclide in the sample container. In the case of vanadium-50 (isotopic abundance 0.25%) a lower limit of the half-life was found to be $9.0 \times 10^{16}$ and $6.9 \times 10^{16}$ years respectively for the two modes of decay $^{50}V-EC-^{50*}Ti-\gamma(1.58\ MeV)-^{50}Ti$ and $^{50}V-\beta^--^{50*}Cr-\gamma(0.78\ MeV)-^{50}Cr$. (auth)

**2687** RESONANCE DETECTOR MEASUREMENTS OF NEUTRON SPECTRA UP TO 3 keV. Zvonarev, A. V.; Koleganov, Yu. F.; Mihalius, F. F.; Nilolaev, M. N. At. Energ. (USSR), 20: 518-20(June 1966). (In Russian).

In view of the difficulties connected with the direct determination of neutron spectra within a reactor, an indirect method based on self-shielded resonance detectors was developed. The method requires knowledge of the self-shielding factor ($\eta$); when elements with high scattering cross sections are used, the multiple scattering must be taken into account. The possibility of using the first resonances of the neutron capture reaction in $^{186}W$, $^{55}Mn$, and $^{23}Na$ was investigated determining the value of $\eta$ for various detector thicknesses, while taking into account the activation of the specimen as the result of the first collision. The neutron energy distribution corresponding to the first resonance was measured for $^{115}In$, $^{197}Au$, $^{186}W$, $^{55}Mn$, and $^{23}Na$ by this method, placing the elements inside a uranium block exposed to Fermi-spectrum neutrons. The results indicated that the above resonance detectors may be used for determining neutron spectra within a reactor. Assuming that the collision density near the resonances is constant, the average neutron flux may also be measured by this method. (TTT)

**2688** REACTION $^{23}Na(p,\gamma)^{24}Mg$ INDUCED BY PROTONS ENERGY BELOW 500 keV. L'Ecuyer, J.; Levesque, R. J. A. (Univ., Montreal). Can. J. Phys., 44: 2201-10(Oct. 1966). (In French).

The yield of the reaction $^{23}Na(p,\gamma)^{24}Mg$ was measured at proton energies from 0 to 450 keV. Three resonances were found at 251, 308, and 374 keV; from measurements made at several angles, the differential cross section of the reaction to each of the resonances was determined. The total capture cross section as well as the spin and reduced width of the $^{24}Mg$ level formed in each case was established. An upper limit for the nonresonant yield was also obtained. The experimental results were used to calculate the yield of the reaction in stars. The calculations confirm the conclusions of Reeves and Salpeter and show that the mechanisms proposed for the formation of $^{24}Mg$ and $^{23}Na$ in stars are, at the least, incomplete. (D.C.W.)

**2689** THE (n,p) CROSS SECTIONS OF TITANIUM ISOTOPES FOR NEUTRON ENERGIES BETWEEN 13.6 MeV AND 19.5 MeV. Pai, H. L. (Univ. of Toronto). Can. J. Phys., 44: 2337-52(Oct. 1966).

Using enriched titanium samples, the activation (n,p) and (n,pn; n,np; n,d) cross sections have been measured for the five isotopes of titanium in the neutron energy range from 13.6 to 19.5 MeV. The results were compared with calculations based primarily upon Bodansky's theory (1962), where the first proton emission cross section was taken to be the sum of (n,p) and (n,pn). The (n,pn) cross section was separated from the experimental (n,pn; n,np; n,d) cross section by a multiple-emission calculation. Using the nuclear temperature derived from the experimental data, good agreement was achieved between experiment and theory. It was found that the parameters of Bodansky's equation for the titanium isotopes could be adopted directly from the mass parabolas (Dewdney 1963). It was also found that the (n,p) cross sections were not influenced appreciably by the neutron closed shell. (auth)

**2690** GAMMA ENERGIES OF $^{66}Ga$ DECAY. Wien, K. (Technische Hochschule, Darmstadt, Ger.). Phys. Lett., 23: 353-5 (Nov. 7, 1966).

The $\gamma$ spectrum of $^{66}Ga$ produced by $^{69}Ga(\gamma,3n)$ was remeasured with a Ge(Li)-detector; 19 $\gamma$ energies between 0.8 and 4.9 MeV, suitable for the calibration of $\gamma$ detectors, are given with an accuracy of 0.8 to 2.5 keV. (auth)

**2691** COLLECTIVE THREE PARTICLE STATES OF $^{43}Sc$. Ripka, G.; Zamick, L. (Centre d'Etudes Nucleaires, Saclay, Gif-sur-Yvette, France). Phys. Lett., 23: 350-2(Nov. 7, 1966).

A complete diagonalization of the three-particle states of $^{43}Sc$ and $^{43}Ca$ using Rosenfeld, Kallio-Kolltveit and Hamada-Johnston forces reveals low-lying low-spin collective states. (auth)

**2692** CASCADE CALCULATION FOR MUONIC LEAD. Huefner, Joerg (Univ., Heidelberg). Z. Phys., 195: 365-9(1966). (In German).

A cascade calculation can not explain the anomalous intensity ratios in muonic Pb and Bi. The muonic transitions $2s \rightarrow 2p$ and $3p \rightarrow 1s$ are discussed, and their intensities are estimated. (auth)

**2693** INVESTIGATION OF THE PREVIOUSLY DESCRIBED $^{196}Ir$ 50-sec ACTIVITY AND NEW RELATION TO THE DECAY OF $^{196}Ir$. Vonach, H.; Muenzer, H.; Hille, P. (Technische Hochschule, Munich. Oesterreichischen Akademie der Wissenschaften, Vienna). Z. Phys., 195: 343-53(1966). (In German).

The short-lived activities produced by 14 MeV neutron irradiation of natural platinum and enriched $^{196}Pt$ were investigated. In this way the 50 sec activity assigned so far to $^{196}Ir$ could be identified as $^{196}Ir$. By investigation of the $\beta$ and $\gamma$ spectra of the 50 sec-activity and $\gamma$-$\gamma$ coincidences, a decay scheme of $^{196}Ir$ could be established. Its main features are: $^{196}Ir$ decays predominantly (75%) to the ground state of $^{196}Pt$ by emission of $\beta$ particles with an endpoint energy of 3.17 ± 0.06 Mev. Weaker $\beta$ branches populate levels of $^{196}Pt$ at 0.35, 0.69, 0.80, and 1.12 MeV, three of these being $2^+$ levels. The log ft values for the different $\beta$-branches range from 5.7 to 6.8, and suggest spin 1 for $^{196}Ir$. The measured decay energy of 3.17 MeV is definitely lower than the value of 3.4 MeV obtained by Bishop for a 2.3 h activity corresponding to a high-spin (9 to 12) state of $^{196}Ir$, thus the latter is obviously an isomer of $^{196}Ir$ with an excitation energy of about 0.2 MeV. (auth)

**2694** STUDY OF THE $^{27}Al(d,\alpha)^{25}Mg$ REACTION. Lin, E. K. (Inst. of Physics, Taiwan, China); Wang, W. N.; Chiao, T.; Lee, T. J.; Hsu, C. C.; Yang, Y. C. Chin. J. Phys. (Taiwan), 4: 6-15 (Apr. 1966).

The alpha particle groups from thin aluminum targets bombarded with 2.0 to 3.0 MeV deuterons were studied with an energy resolution of ~90 keV. Eight of these groups were observed, corresponding to the ground state and excited states of $^{25}Mg$ with excitation energy of 0 to 3.40 MeV. Angular distributions of various alpha particle groups were measured from 35 to 155°, and excitation functions at 45° were measured in the bombarding energy range from 2.0 to 3.0 MeV. Total cross sections of alpha particle groups averaged over four bombarding energies from $E_d = 2.36$ MeV to $E_d = 2.92$ MeV and integrated over angles from 35 to 155° were compared with the (2I + 1) rule. These were also compared with previous measurements by Jahns and by Hansen. (auth)

**2695** SHELL-MODEL CALCULATION OF THE $^{49}Sc$ SPECTRUM. Bertsch, G. F. (Univ. of Copenhagen); Damgaard, J. Phys. Lett., 23: 342-4(Nov. 7, 1966).

The single-particle states of $^{49}Sc$ are strongly affected by low lying 2p-1h excitations of the structure $\left(\begin{matrix} n \\ p_{\frac{3}{2}} \end{matrix}\left[\begin{matrix} p\ n^{-1} \\ f_{\frac{7}{2}}\ f_{\frac{5}{2}} \end{matrix}\right]_L\right)_J$. These 2p-1h states are not very much higher in energy than the $p_{\frac{3}{2}}$ single-particle states. (auth)

**2696** SINGLE-PARTICLE-COLLECTIVE MODEL FOR $^{59}Ni$. Azziz, N. (Westinghouse Atomic Power Div., Pittsburgh). Phys. Lett., 23: 337-41(Nov. 7, 1966).

The level structure of $^{59}Ni$ was described by a simple model that couples neutron single-particle motions with the normal modes of the collective motion of $^{58}Ni$ which is assumed to be a vibrational nucleus. The model is a generalization of that described by Brown

and Lande and is in agreement with the ideas developed in the coupled-channel formalism. Predictions of the model are compared with (d,p) stripping reaction and neutron spectroscopy experiments. (auth)

**2697** ANGULAR CORRELATION AND LIFETIME MEASUREMENTS IN $^{30}$Si USING A Ge(Li) DETECTOR. Broude, C.; Smulders, P. J. M.; Alexander, T. K. (Chalk River Nuclear Labs., Ont.). Nucl. Phys., 6701A: 321-33(1967).

Gamma rays from the decay of the first four excited states of $^{30}$Si were observed with a 25-cm$^3$ Ge(Li) detector following the reaction $^{27}$Al($\alpha$,p)$^{30}$Si. The cascade decays of the 3.767- and 3.786-MeV states are clearly resolved. The 3.767-MeV state decays to the ground and first excited states in the ratio 38:62; the 3.786-MeV state decays entirely to the first excited state. The observed Doppler shifts of the gamma rays from the first four excited states indicate their respective lifetimes to be 4.7 ± 0.5, 1.5 ± 0.2, 1.0 ± 0.2, and >12 in units of $10^{-13}$ sec. Gamma–gamma coincident angular correlations were measured for the 3.767- and 3.786-MeV states using a 12.7-cm-diameter × 15.2 cm-long NaI(Tl) crystal for the second detector. The correlation for the 3.786-MeV state assigns spin zero uniquely, while that for the 3.767-MeV state is consistent with spins 1, 2, or 3. Spin 3 is ruled out by the lifetime estimate and the observed branching ratio. (auth)

**2698** SOME PROPERTIES OF LOW LEVELS IN $^{43}$Sc. Phillips, W. R.; de la Pena, R.; Critchley, T. A. (The Univ., Manchester, Eng.). Nucl. Phys., 6701A: 379-400(1967).

The reaction $^{40}$Ca($^4$He,p)$^{43}$Sc was used to study excited states of $^{43}$Sc below 1.7 MeV. The chief modes of decay of the levels, and in some cases their spins, were determined by measuring the angular correlations between decay gamma rays and the appropriate proton groups. These were observed at near 180° in an annular solid-state detector. Experiments were made at $^4$He bombarding energies of 9.0 and 9.35 MeV. Nine excited states above the ground state were observed at energies of 0.151, 0.472, 0.849, 0.880, 1.158, 1.181, 1.341, 1.414, and 1.644 MeV. The p-$\gamma$ correlations establish spins of $^5/_2$ for the 0.880-MeV level and $^7/_2$ for the 1.341-MeV level. The following scheme is suggested by all the data available: 0.151-MeV level, spin and parity $^3/_2^+$; 0.472, $^5/_2^-$($^5/_2^+$); 1.849, ($^5/_2^+$); 0.880, $^5/_2^+$; 1.158, ($^5/_2^+$); 1.181, unknown; 1.341, $^7/_2^+$; 1.414, ($^7/_2^+$); 1.644, ($^5/_2^+$, $^3/_2^-$). (auth)

**2699** ISOBARIC ANALOGUE RESONANCES IN (p,n) REACTIONS ON $^{74}$Ge, $^{107}$Ag, $^{109}$Ag, AND $^{141}$Pr. Harchol, M.; Jaffe, A. A. Zioni, J.; Drory, Ch. (Hebrew Univ., Jerusalem). Nucl. Phys., 6701A: 473-9(1967).

Excitation functions for the reactions $^{74}$Ge(p,n)$^{74}$As, $^{107}$Ag(p,n)$^{107}$Cd, $^{109}$Ag(p,n)$^{109}$Cd, and $^{141}$Pr(p,n)$^{141}$Nd were investigated, and isobaric analog resonances were identified. The Coulomb displacement energies for the isobaric pairs $^{75}$Ge–$^{75}$As, $^{108}$Ag–$^{108}$Cd, $^{110}$Ag–$^{110}$Cd, and $^{142}$Pr–$^{142}$Nd were found to be 10.00 ± 0.04, 13.30 ± 0.04, 13.19 ± 0.04, and 15.36 ± 0.05 MeV, respectively. The widths of the analog resonances are presented and are discussed. (auth)

**2700** LONGITUDINAL POLARIZATION OF BETA PARTICLES. Lazarus, Donald Martin. New Haven, Yale Univ., 1966. 212p.

Thesis.

The Mott scattering method in which spin-dependent scattering of electrons produces an asymmetry in intensity distribution was employed to measure the v/c dependence of the longitudinal polarization of beta particles emitted in the decay of $^{60}$Co from v/c = .41 to .70. Particular emphasis was placed on the evaluation of the systematic errors associated with the technique. Measurements of the geometric asymmetry, the effect of multiple and plural scattering, scattering in the source and from the source backing were carried out. The prediction of the two component neutrino theory, that the polarization in an allowed decay is ± v/c was confirmed for the first time over a large range of momenta for a single emitter. An average result of P/(v/c) = 1.023 ± .024 was obtained. (Dissertation Abstr.)

**2701** A STUDY OF THE REACTIONS $^{39}$K(d,$^4$He)$^{37}$A AND $^{39}$K(p,$^4$He)$^{36}$A. Rawlins, John Archer. Austin, Tex., Univ. of Texas, 1965. 90p.

Thesis.

The excitation function for the reaction $^{39}$K(p,$\alpha_0$)$^{36}$Ar was measured in 2-keV steps from 3 to 4 MeV and in 5-keV steps from 4 to 7 MeV at laboratory angles of 90 and 155°. The targets were natural potassium chloride evaporated onto thin carbon backings. Many resonances were observed, and angular distributions were taken at several of these resonances in 10° intervals from 30° to 160°. The analysis was based on an extension of the single-level formalism to the case of many closely-spaced levels. The observed average spacing of levels in the compound nucleus $^{40}$Ca was 19 keV. The alpha-particle strength function was found to be 0.005, within a factor of 2. There was no evidence for a direct-reaction mechanism. The excitation function for the reaction $^{39}$K(d,$^4$He)$^{37}$Ar was measured at 90 and 160° from 3 to 4 MeV in 20-keV steps for alpha particles leading to the first six states in $^{37}$Ar. Angular distributions were taken in 10° intervals from 30 to 160° at bombarding energies of 3.2, 3.4, 3.6, and 3.8 MeV. The targets were natural potassium iodide evaporated onto thin carbon backings. The results were explained on the basis of Ericson's theory of statistical fluctuations, and the correlation energy of the compound nucleus $^{41}$Ca was found to be 35 keV ± 15 keV. There was no evidence for any direct reaction mechanism. (Dissertation Abstr.)

**2702** THE MEASUREMENT AND ANALYSIS OF SOME 9-MeV (d,$\alpha$) DIFFERENTIAL CROSS SECTIONS FOR $^{19}$F, $^{23}$Na, $^{27}$Al, AND $^{31}$P. Cosper, Sammie Wayne. Lafayette, Ind., Purdue Univ., 1965. 129p.

Thesis.

The differential cross sections for the (d,$\alpha$) reactions which lead to various nuclear states in $^{17}$O (gnd., 1,2,3, and 4), $^{21}$Ne (gnd., 1, and 2), $^{25}$Mg (gnd., 1, 2, 3, and 4), and $^{29}$Si (gnd., 1, 2, 3, 4, 5, and 6) were measured at nominal deuteron energies of 9.2, 9.2, 9.2, and 9.5 MeV respectively. The charged-particle spectra were measured using a silicon surface-barrier detector and a conventional electronics configuration. Targets of various thicknesses ranging from 70 to 720 $\mu$g/cm$^2$ were used. In each case the differential cross section was determined at more than 34 angles from 10 to 172.5°. Although the shape of each angular distribution is different than any of the others in detail, all exhibit the following characteristics: pronounced forward and backward peaking; an overall oscillatory structure; an asymmetry about 90°; and minima whose magnitudes differ significantly from zero. Comparisons are made with (d,$\alpha$) results which have been previously obtained by other investigators using deuteron energies in the 7-15 MeV range. No correlation could be established between any specific detail in shape or general feature of these angular distributions and any physical quantity associated with the nuclear states involved. A discussion regarding the identification of either the pick-up or knock-out mechanism as the dominant forward-angle direct-interaction process for (d,$\alpha$) reactions in light nuclei is presented. It is concluded that the experimental angular distributions are fit equally well irrespective of which one is assumed to act along with heavy particle stripping. Analyses of these differential cross sections in terms of an expression consisting of the sum of an isotropic component and a PWBA component which arises from the coherent action of a two-nucleon pick-up and a heavy-particle-stripping mechanism are described. (Dissertation Abstr.)

**2703** GAMMA- AND BETA-RAY SPECTROSCOPY STUDIES OF THE RADIOACTIVE DECAY OF $^{51}$Mn TO $^{51}$Cr. Glibert, Kenneth Malcolm. Corvallis, Oreg., Oregon State Univ., 1966. 126p.

Thesis.

The decay scheme of $^{51}$Mn was investigated using gamma and beta scintillation spectrometers and a fast coincidence spectrometer. A half-life value of 46.5 ± 0.2 min was determined for $^{51}$Mn which decays predominantly to the ground state of $^{51}$Cr by the emission of positons with an experimentally measured end-point energy of 2.21 ± 0.02 MeV. Weak branching to the 761- and 1170-keV levels of $^{51}$Cr, however, was inferred from the measured 761 ± 11- and 1170 ± 15-keV gamma energies observed in the $^{51}$Mn gamma spectrum. Relative intensities for these weak gamma rays were determined experimentally as 0.70 ± 0.10 and 0.48 ± 0.12 percent of the positons, respectively. An 11 ± 1-nsec mean life was obtained for the 761-keV level of $^{51}$Cr while an upper limit of 1 nsec was given to the 1170-keV level. Using these experimental results coupled with theory, a spin and parity assignment of $^5/_2^-$ was given to the ground state of $^{51}$Mn, a spin assignment which is not in agreement with the $^7/_2^-$ value expected from the shell-model prediction. (Dissertation Abstr.)

**2704** GAMMA-RAY ANGULAR CORRELATION STUDIES ON LEVELS OF $^{28}$Si AND $^{29}$Si. Ferguson, A. J.; Alexander, T. K.; Broude, C.; Kuehner, J. A.; Lither, A. E.; Ollerhead, R. W.; Smulders, P. J. M. (Atomic Energy of Canada Ltd., Chalk River, Ont.). 9p. (CONF-660639-2). ORAU. Gmelin, AED-CONF-66-221-3.

From Congress-Canadian Association of Physicists, Sherbrooke, Quebec.

Equipment is described which can be used for studying triple angular correlations in particle–gamma–gamma experiments. The equipment consists of an array of 7 NaI counters for which there are 42 combinations of direction for two emergent $\gamma$ rays, each combination representing an independent measurement of the triple correlation. With recording equipment capable of recording all these combinations, the complete correlation can be measured in a single run. Results are presented on the use of the equipment for angular correlation studies on the reaction $^{29}$Si(p,p'$\gamma\gamma$)$^{29}$Si and for levels in $^{28}$Si. (S.F.L.)

# Nuclear Properties and Reactions, A ≥ 90

*Refer also to abstracts 1312, 1593, 1613, 2355, 2601, 2603, 2608, 2617, 2630, 2651, 2660, 2667, 2671, 2684, 2687, 2699, 2764, 2765, 2772, 2777, 2791, 2807, 2808, and 2810.*

**2705** (COO-1546-3) ANALYSIS OF NEUTRON RESONANCES IN FISSILE ELEMENTS: PROGRAMS CODILLI, CURVEPLOT, AND SIGMA. Adler, D. B.; Adler, F. T. (Illinois Univ., Urbana, Dept. of Physics). Sept. 1966. Contract AT(11-1)-1546. 110p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

An interrelated group of programs was developed for the analysis of low-energy neutron cross sections of fissile elements. The method of analysis is based on the multilevel expansion of the cross sections. The basic program, CODILLI, consists of a combination of interdependent subroutines. This facilitates not only the adaptation to other computers but it also allows freedom to incorporate specific experimental information such as resolution functions or statistical errors. The numerical determination of the resonance parameters is performed by the standard least squares techniques which make use of the Gauss linearization method for nonlinear trial functions. Program SIGMA provides for the calculation of capture and scattering cross sections from fitted total and fission cross section data, as well as for various methods of comparing different cross-section models. Program CURVEPLOT provides for multilevel analysis without least-squares fitting and for a graphical representation of the sections by means of a CALCOMP plotter. A description of the programs is given together with the listings in the FORTRAN II version. (auth)

**2706** (GA-7076) NEUTRON CROSS SECTIONS FOR $^{233}U$. Drake, M. K. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Sept. 15, 1966. Contract AT(04-3)-167. 123p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

The available nuclear data for $^{233}U$ were critically analyzed, and recommended sets of neutron cross sections were obtained. Comparisons were made between resonance integrals obtained from the recommended data and those obtained from experimental measurements. The complete sets of neutron cross sections and associated data are presented in graphical and tabular form. The survey is believed to be complete for information available to March 1966. (S.F.L.)

**2707** (ORNL-3994, pp 1-26) NUCLEAR CHEMISTRY. (Oak Ridge National Lab., Tenn.).

The irradiation of a particularly pure sample of $^{236}U$ in the high-flux reactor at Savannah River and a mass analysis of the $^{238}U$ formed permitted a preliminary estimate of approximately 100 barns to be made for the reactor neutron capture cross section of $^{237}U$. The reactor cross sections of $^{110}Cd$, $^{111}Cd$, and $^{112}Cd$ were measured as 11 ± 2, 24 ± 3, and 2.2 ± 0.5 barns, respectively. The irradiation of $^{104}Ru$ and mass analysis of the palladium produced permitted calculation of a thermal cross section $\sigma_{th}$ = 14.4 ± 1.5 kilobarns and a resonance integral of 17 ± 3 kilobarns for 36-hr $^{105}Rh$. The thermal neutron capture cross sections and resonance integrals of $^{139}La$ and $^{140}La$ were measured by determining the $^{140}La$ and $^{141}Ce$ produced in high-flux irradiations. The neutron cross section and resonance integral of 7.5-day $^{111}Ag$ were determined from measurements of the 3.2-hr $^{112}Ag$ formed in reactor irradiations and are reported as 3.2 ± 2 and 105 ± 20 barns, respectively. The fractional cumulative yield of $^{115}Pd$ from $^{235}U$ thermal-neutron fission was measured to be 0.883 ± 0.020. The fractional cumulative fission yields for $^{143}Ba$ and $^{144}Ba$ from $^{235}U$ thermal-neutron fission indicated that the nuclear charge distributions for these masses continue the trends observed for lighter fission products in the heavy-mass peak. Cumulative yields of $^{103}Mo$, $^{105}Mo$, and $^{106}Mo$ fission products were shown to include large fractions of their respective chain yields. Thus from uranium fission, fragments with Z > 42 seem to be formed with small probability. One may infer that this is due to the difficulty of forming the complementary fission fragments with Z < 50, where the strong 50-proton shell may affect fragment yields. Gamma rays accompanying compound-nucleus reactions produced by bombarding $^{93}Nb$, $^{94}Zr$, and $^{114}Cd$ with 40- to 60-MeV alpha particles were measured with Ge(Li) detectors. Levels in $^{94}Zr$ were studied by inelastic scattering of 12.7-MeV protons. Energies for 34 excited states in $^{92}Mo$ were determined by analyzing data from inelastic scattering of 10-MeV protons and from the associated gamma spectrum. From the decay of the 53-min and 5-hr isomers of $^{94}Tc$, measured with Ge(Li) and NaI detectors, a level scheme was constructed and compared with shell-model predictions. The decay of isomers of $^{130}I$ was investigated with Ge(Li) and NaI(Tl) detectors, with a single-gap toroidal field spectrometer, and with coincidence techniques. The upper isomer, in addition to independent beta decay, decays to the ground state via a 48.2-keV M3 transition. A detailed study was made on the levels in $^{184}W$ populated in the decay of 8.7-hr $^{184}Ta$. The level scheme proposed as a result of these measurements includes at least 17 states in $^{184}W$ and 27 associated gamma transitions. Among the levels observed are members of the ground-state rotational band up through the $6^+$ state, the $2^+$, $3^+$, and $4^+$ members of the γ-vibrational band, and a group of levels above 1285 keV, which appear to belong to an intrinsic two-quasi-particle excitation. The gamma rays from the decay of 12.4-year $^{152}Eu$ were studied with high-resolution germanium detectors as well as by gamma-gamma coincidence experiments that utilize a multiparameter analyzer. These studies disclosed several new features of the level schemes of $^{152}Gd$ and $^{152}Sm$, including the population of an additional member of the β-vibrational band in the latter. The gamma spectrum of $^{80m}Br$ was studied by means of a lithium-drifted germanium detector and NaI coincidence spectrometers in conjunction with a three-dimensional multichannel analyzer. From these measurements, level schemes in $^{80}Se$ and $^{80}Kr$ populated from the decay of $^{80m}Br$ are proposed. High-resolution measurements of the gamma spectrum of $^{154}Eu$ revealed several features of the excited levels in $^{154}Gd$. The energy levels populated by the decay of $^{136}Pr$ and $^{137}Pr$ in the respective cerium isotopes were deduced from observed gamma energies, intensities, and coincidences. A total decay energy of 5.07 ± 0.05 MeV was derived for 13.5-min $^{136}Pr$ from quadruple coincidence measurements using one anthracene and three sodium iodide detectors. (auth)

**2708** (UCRL-16995) NEW DATA ON THE DECAY OF $^{177m}Lu$. Haverfield, A. J.; Bernthal, F. M. (Lawrence Radiation Lab., Univ. of California, Berkeley). July 1966. Contract W-7405-eng-48. 9p. (CONF-660906-26). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

A lithium-drifted germanium detector having a resolution of 1.3 keV at 122 keV was used to examine the gamma-ray spectrum of $^{177m}Lu$. Three new transitions have been found which fit into the previous decay scheme. Gamma-ray relative intensity measurements have been used to derive many of the parameters associated with the unified nuclear model. Of particular interest is the comparison of derived E1 transition probabilities to simple theory. (auth)

**2709** (UCRL-16996) LEVELS OF $^{188}Os$ POPULATED BY $^{188}Re$ AND $^{188}Ir$. Yamazaki, T.; Sato, J.; Yokoyama, Y.; Baba, S.; Ikegami, H.; Sakai, M. (Lawrence Radiation Lab., Univ. of California, Berkeley). July 1966. Contract W-7405-eng-48. 12p. (CONF-660906-27). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

On the basis of an experimental study of the $^{188}Re$ and $^{188}Ir$ decays to $^{188}Os$, some remarkable features, such as the nature of the lowest K = 2 band, the 0+ states, and the beta decay modes to quasiparticle states, are discussed. (auth)

**2710** NUCLEAR REACTIONS ON Ir, Ta, AND Er, INDUCED BY PROTONS WITH ENERGIES UP TO 85 Mev. Barashenkov, V. S.; Mal'tsev, V. M.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 232-4(Feb. 1966). (In Russian).

Monte Carlo calculations of excitation functions for (p,xn) reactions (x = 1, 2, 3, . . .) were performed under the following assumptions concerning the reaction mechanism: the target nucleus is excited by capture of the incident proton with formation of a compound nucleus; and collision of the primary proton with the target nucleus gives rise to a intranuclear cascade, after which the nucleus is left in an excited state. It was assumed in both cases that de-excitation is realized by evaporation of nucleons. The calculated excitation curves were compared with experimental data on the Ir, Ta, and Er reactions at proton energies from 8 to 85 MeV. Comparison of the calculations with experimental data for the $^{181}Ta$ (p,xn) reactions for x = 1, 3, 4, 5, and 6 showed that the contribution of compound-nucleus formation decreases smoothly from 100% at proton energies below 20 MeV to about 20% at a proton energy of 85 MeV. The calculated excitation functions were in quantitative agreement with the experimental data, except for the cases x = 1 and x = 4 where the derivations somewhat exceeded the experimental error. The dependence on proton energy of the relative contribution of the two reaction mechanisms derived from the $^{181}Ta$ (p,xn) data was employed to calculate excitation functions for $^{181}Ta$ (p,pxn) reactions and for reactions on Ir and Er. Satisfactory agreement with the experimental data was found. The agreement was particularly good for the $^{181}Ta$ (p,4n) reaction. It is concluded that the cascade-evaporation model gives a correct qualitative, and in some cases a quan-

titative, description of the nuclear interaction process in the 20 to 80 MeV incident particle energy range, but that it is not in a position to account for some details, such, for example, as (p,n) exchange scattering, fluctuations of the total interaction cross section, and quasifree scattering with subsequent emission of one or two neutrons. The model could be improved by introducing a diffuse nuclear boundary. (ATD)

**2711** DECAY OF $^{162}$Tb TO LEVELS IN $^{162}$Dy. Schima, Francis J. (Indiana Univ., Bloomington). Phys. Rev., 151: 950-5 (Nov. 18, 1966).

The $^{162}$Tb beta decay to levels in $^{162}$Dy was studied by means of scintillation spectrometers and a Ge(Li) detector. The sources of the $^{162}$Tb activity were obtained from the $^{162}$Dy(n,p)$^{162}$Tb reaction. The half life of the $^{162}$Tb activity was measured to be 7.75 ± 0.31 min. Gamma transitions (with intensities in percent of total Tb decays) observed are: 81.0 ± 0.8 (65%), a complex 184.5 ± 0.4 (19%), 259.2 ± 0.6 (72%), 805.2 ± 1.2 (45%), 881.5 ± 3.5 (15%), and 887.5 ± 1.5 keV (35%). Gamma transitions of 620 ± 30, 690 ± 25, and 1070 ± 30 keV are tentatively indicated. A $^{162}$Dy level scheme is proposed with levels at 887.5 ($2^+$, K = 2), 962.2 ($3^+$, K = 2), and 1147 keV ($2^-$ or $3^-$, K ≥ 2). Alternative placement of several transitions is discussed. Measurements of the beta spectrum yield a strong 1375 ± 50-keV branch (log ft = 5.1 ± 0.2) to the 1147-keV level, a tentative branch (<10%, log ft > 6.4) to the 887.5-keV level, and no indication of a branch to the levels in the ground-state rotational band. (auth)

**2712** DECAY OF $^{103}$Ag. Jackson, A. D. Jr. (Princeton Univ., N. J.); Evans, J. S.; Naumann, R. A.; McCullen, J. D. Phys. Rev., 151: 956-60(Nov. 18, 1966).

Natural palladium foil was irradiated with 18-MeV protons to produce 1.1-hr $^{103}$Ag by (p,xn) reactions. The target foil was placed directly into the ion source of the Princeton isotope separator, and the silver isotopes were volatilized, dispersed, and collected. Spectroscopic data were obtained using Ge(Li) gamma detectors, an orange-type electron spectrometer, and permanent magnet spectrographs. Transitions were observed at 118.66, 148.26, 244.5, 266.9, 532.2, (555.9), 578.8, 741.9, 940.6, 1007.1, 1030.3, 1155.8, 1183.6, and 1274.6 keV. Energies of doubtful transitions are mentioned in parentheses. Gamma spectra in coincidence with several conversion-electron lines, taken with a NaI (Tl) detector in conjunction with the orange spectrometer, gave evidence for levels in $^{103}$Pd at 0, 118.7, 244.5, 266.9, (532), (823), (1184), and 1274.4 keV. (auth)

**2713** NEW ISOMER: 5.3-hr $^{103}$Mo. Ganapathy, R.; Ihochi, H.; Kuroda, P. K. (Univ. of Arkansas, Fayetteville). Phys. Rev., 151: 960-3(Nov. 18, 1966). (COO-3235-2)

Fission of $^{238}$U and $^{232}$Th induced by 14.8-MeV neutrons was found to produce a new radioactive nuclide which was assigned to a $^{103}$Mo isomeric state. The following radiation characteristics were observed to belong to the decay of the $^{103}$Mo isomer: half life, 5.3 ± 0.2 hr; gamma energies of 0.54 ± 0.03, 1.13 ± 0.06, 1.26 ± 0.06, 1.46 ± 0.10, and 1.70 ± 0.10 MeV; and relative intensities of 100, 28.9 ± 2.0, 42.9 ± 4.0, 13.6 ± 2.0, and 36.8 ± 4.0, respectively. The production ratio of this new nuclide to $^{99}$Mo in the 14.8-MeV neutron-induced fission of $^{238}$U and $^{232}$Th was found to be 0.010 ± 0.002 and 0.015 ± 0.002, respectively. (auth)

**2714** EVIDENCE FOR A $7/2^+$ STATE IN $^{93}$Mo. Alexander, Peter; Scharff-Goldhaber, Gertrude (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Phys. Rev., 151: 964-9(Nov. 18, 1966). (BNL-10351).

The recent shell-model calculations by Bhatt and Ball and by Auerbach and Talmi concerning the level locations and transition probabilities in $^{93}$Mo prompted an experimental examination of the $^{93}$Mo level scheme. This level scheme was studied through the decays of 7-hr $^{93m}$Mo, 44-min $^{93m}$Tc, and 2.8-hr $^{93}$Tc. The gamma spectra produced in these decays were examined with a Ge(Li) detector and with Ge(Li)-NaI(Tl) coincidence techniques. A previously unreported transition of 114 keV, observed in the decay of $^{93m}$Mo, populates a level in $^{93}$Mo at (1365 ± 3) keV. A spin-parity $7/2^+$ is assigned to this level. The γ ray previously reported at 1.5 MeV in the spectrum of 2.8-hr $^{93}$Tc was shown to consist of a doublet at 1.477 and 1.521 MeV, and a previously unreported γ ray at 2.734 MeV was observed. The absence of transitions of 2030 and 2440 keV, which were previously reported to exist, is also of interest. An interpretation of these results in terms of the shell-model calculations is discussed. (auth)

**2715** ANALYSIS OF PROTON SCATTERING FROM $^{92}$Zr AND $^{94}$Zr AT 19.4 MeV. Stautberg, M. M.; Kraushaar, J. J. (Univ. of Colorado, Boulder). Contract AT(11-1)-535. Phys. Rev., 151: 969-83(Nov. 18, 1966). (UCOL-535-557).

Elastic and inelastic angular distributions for 19.4-MeV protons scattered from $^{92}$Zr and $^{94}$Zr were measured. Several deuteron and triton groups from the (p,d) and (p,t) reaction were observed, and angular distributions were obtained. The inelastic distributions were analyzed using the real and complex collective-model form factor to obtain level-structure information. Angular distributions for several states of $^{92}$Zr and $^{94}$Zr were compared with distorted-wave calculations using shell-model wave functions for the initial and final nuclear states. An effective internucleon potential, which was found from the analysis of proton scattering from $^{90}$Zr, was used and consisted of a Yukawa potential with a range of 1 F and a depth of approximately 200 MeV. This model was successful in predicting the magnitude and shape for the $^{92}$Zr and $^{94}$Zr cross sections for states having the $(d_{5/2})^2$ and $(d_{5/2}d_{3/2})$ configurations in $^{92}$Zr and the $(d_{5/2})^{-2}$ configuration in $^{94}$Zr. (auth)

**2716** DYNAMIC PENETRATION EFFECTS IN THE INTERNAL CONVERSION OF ELECTRIC DIPOLE TRANSITIONS IN $^{175}$Lu. Emery, G. T. (Brookhaven National Lab., Upton, N. Y. State Univ. of New York, Stony Brook); Perlman, M. L.

Contract AT-(30-2)-Gen-16. Phys. Rev., 151: 984-92(Nov. 18, 1966). (BNL-10213).

Internal-conversion coefficients are reported for the 396.3-, 282.5-, and 144.8-keV electric dipole transitions in $^{175}$Lu; these occur between the 396.3-keV, $9/2^-$ state of the [514↑] band and the $7/2^+$, $9/2^+$, and $11/2^+$ members of the ground-state [404↓] band. Values for K and $L_1$ shells were determined directly, and for the $L_2$ and $L_3$ shells the coefficients were obtained from the $L_1$ and K values and the $L_1 : L_2 : L_3$ ratio measurements of Herrlander and Ewan. The dynamic penetrations terms, $j \cdot \nabla$ and $j \cdot r$, and the M2 admixtures were determined. For the 282.5-keV transition, additional information from Thun et al. on the electron-gamma angular correlation was used in the analysis. The amounts of M2 admixture were found to be small, the $j \cdot \nabla$ nuclear matrix elements are consistent with zero, and the $j \cdot r$ matrix elements are in good agreement with rotational-model predictions. (auth)

**2717** CONCERNING NUCLEAR FISSION. Cherdantsev, P. A.; Marshalkin, V. E. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 341-2 (Feb. 1966). (In Russian).

A simple model of nuclear fission is presented in which shell-model, single-particle, and collective effects are taken into account. In the model presented, the nucleus undergoing fission is treated as two intersecting spherical fragments, and the energies of the eigenstates of a nucleon in the field of the intersecting fragments are used to construct a potential energy function for the collective motions. The energy barrier against fission of $^{238}$U was calculated as a function of the distance between the centers of the two intersecting spherical fragments for different values of the asymmetry parameter. The barrier against symmetric and highly asymmetric fission was found to be higher than that against moderately asymmetric fission. (ATD)

**2718** CALCULATION OF FAST-PARTICLE-INITIATED NUCLEAR FISSION. Barashenkov, V. S.; Mal'tsev, V. M.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 337-40(Feb. 1966). (In Russian).

Monte Carlo calculations of the fission of $^{238}$U induced by up to 700-MeV protons were performed on the basis of the cascade-evaporation model and the statistical theory of fission of Fong (Phys. Rev., 102: 434 (1956)); the results were compared with experimental data. $^{238}$U was chosen for the calculations because the most experimental data are available for it. The calculations are described very briefly. Legendre polynomials up to only the third degree were employed in the expressions for the shapes of the fragments at the moment of fission, but the effect of higher powers of the deformation factor on the Coulomb energy was taken into account by the use of effective deformation parameters that were calculated by a successive approximation method. It is asserted that that technique made it possible more simply to obtain the same results as those obtained with the use of Legendre polynomials up to the 15th degree. The position of the maximum of the theoretical curve giving yield as a function of fragment mass for fissions initiated by 340-MeV protons was in good agreement with that of the experimental curve of Stevenson, Hicks, Nervik, and Nethaway (Phys. Rev., 111: 886 (1959)) and the calculated total fission cross section was in good agreement with experimental values, but the calculated yield for highly asymmetric fission was significantly below the experimental yield. That discrepancy is ascribed to an unspecified simplification employed in the calculations. The calculated yields of $^{134}$Cs–$^{137}$Cs fragments as functions of the incident proton energy were in good agreement with experimental data (when adjusted to the experimental yields at a proton energy of 350 MeV) for proton energies above 200 MeV. The experimental yields of $^{135}$Cs and $^{137}$Cs at lower proton enrgies were considerably higher than the calculated yields, and it is suggested that the discrepancy may be

due to the effect of a second fission mechanism. It is concluded that the statistical theory of fission, together with the cascade-evaporation model, gives a good account of the main features of the fission of heavy nuclei initiated by particles with energies above 200 MeV, but that the fission of heavy nuclei by lower-energy particles requires further study. (ATD)

**2719** QUASI-STATIONARY SINGLE-PARTICLE STATES IN $^{208}$Pb. Korotkikh, V. L; Moskovkin, V. M.; Yudin, N. P. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 319-21 (Feb. 1966). (In Russian).

The energies of 25 quasi-stationary neutron states and 26 quasi-stationary proton states in $^{208}$Pb were calculated. Somewhat over half of the calculated levels lie in the continuous spectrum, in the $7\hbar\omega$ and $8\hbar\omega$ neutron shells, and in the $6\hbar\omega$ and $7\hbar\omega$ proton shells. The energy of a quasi-stationary level was regarded as that at which the derivative of the scattering phase was a maximum. The calculations were undertaken to provide data for calculating the perturbations of the giant dipole and quadrupole resonances. (ATD)

**2720** INTERACTION OF FAST PROTONS WITH HEAVY NUCLEI. Barashenkov, V. S.; Mal'tsev, V. M.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 322-7(Feb. 1966). (In Russian).

Monte Carlo calculations of the interaction of 10- to 700-MeV protons with $^{238}$U nuclei were performed on the basis of the cascade-evaporation model, and the results were compared with experimental data from different sources. $^{238}$U was chosen for the calculations because ample experimental data are available for it. For the calculations it was assumed that the nuclear radius is $1.3A^{1/3} \times 10^{-13}$ cm, and calculations were performed for the two values A/10 and A/20 MeV$^{-1}$ for the level density. Comparisons of the calculated results with experimental data are presented for the following features of the process: the fission and total inelastic interaction cross sections as functions of proton energy; the angular distributions of the charged particles ejected by 460- and 660 MeV protons; the energy distributions of protons and $\alpha$ particles accompanying fission induced by 660-MeV protons; the distributions of fissions induced by 140-, 460-, and 660-MeV protons with respect to the number of accompanying charged particles; the number of moderate-energy ejected neutrons as a function of the proton energy; and the cross sections for producing different fragments as functions of the mass number of the fragment. In general, rather good agreement was obtained between theory and experiment. The agreement was better, and in some cases much better, when the A/10 MeV$^{-1}$ level spacing was used in the calculations than when the A/20 MeV$^{-1}$ spacing was used. The ratio of the fission width to the evaporation width given as a function of energy by a statistical theory was used to calculate the yields of Np, U, Pa, Th, and As fragments as functions of their mass numbers. The calculations for Pa, Th, and As were in agreement with the experimental data, but the calculated yields of Np and U fragments were considerably higher than the experimental yields. The discrepancy is ascribed in part to neglect of quasi-elastic scattering in the calculations, and in part to the fact that the experimental cross sections of Linder and Osborne (Phys. Rev., 103: 378 (1956)) are too low. It is concluded that the cascade-evaporation model and the statistical theory of heavy nucleus fission are in good agreement with experiment in the energy range from 100 to 660 MeV, but that there are discrepancies regarding the yields of certain fragments that can be removed only by taking into account quasi-elastic scattering and the lowering of the Coulomb barrier in excited nuclei, and by a more thorough treatment of the competition between fission and evaporation. (ATD)

**2721** NATURE OF THE WIDTH OF THE DIPOLE RESONANCE IN PHOTONUCLEAR REACTIONS. Zhivopistsev, F. A.; Moskovkin, V. M.; Yudin, N. P. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 306-11(Feb. 1966). (In Russian).

The anomalous width of the dipole resonance in heavy nuclei to the interaction of the dipole level with nuclear configurations whose energies are near that of the dipole level but which themselves do not, or practically do not, carry dipole transitions, and in particular, to interaction with configurations consisting of two particle-hole pairs of which one arises from promotion of a nucleon from a filled state with $j = l + 1/2$ to a free state with $j = l - 1/2$ and the other is a particle-hole pair of the type considered in the usual treatment of the dipole resonance. The matrix elements coupling the two particle-hole pair configurations to the single particle-hole configurations are written for the case of a delta-function Wigner interaction. The density of the two particle-hole states in $^{208}$Pb, their distribution with respect to the angular momenta of the two pairs, and their contribution to the width of the dipole resonance under the assumption that they interact incoherently with it were calculated. The results of those calculations, but not the calculations themselves, are presented. It is concluded that interaction with the two particle-hole pair states increases the width of the dipole resonance in $^{208}$Pb from the standard R-matrix theory value of some 200 keV to approximately 3 MeV (which may be compared with the experimental value of about 4 MeV), and that all the two particle-hole pair states of the type considered, with arbitrary allowed values of the angular momentum of the secondary pair, contribute significantly to the width of the dipole resonance. Most of the discussion is limited to the case of magic nuclei; it is concluded, however, that in nonmagic nuclei the dipole resonance should be even broader. (ATD)

**2722** SCATTERING OF KILOVOLT NEUTRONS BY LEAD AND ELECTRIC POLARIZABILITY OF THE NEUTRON. Aleksandrov, Yu. A.; Samosvat, G. S.; Sereeter, Zh.; Sor, Tsoi Gen (Joint Inst. for Nuclear Research, Dubna, USSR). JETP Lett. (USSR)(Engl. Transl.), 4: 134-7(Sept. 1, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redkat., 4: 196-200(Sept. 1, 1966).

A value for the electric polarizability of the neutron was obtained from experimental observations on neutron scattering by lead at 0 to 26 keV. (D.C.W.)

**2723** COINCIDENCE MEASUREMENTS OF $^{183}$Ta → $^{183}$W DECAY USING AN IRON-FREE ORANGE-TYPE BETA SPECTROMETER. Moll, E.; Gruber, U. (Technische Hochschule, Munich). Z. Phys., 197: 113-23(1966). (In German).

The decay of $^{183}$Ta has been studied using an iron-free orange-type beta-ray spectrometer. Beta–gamma coincidence measurements confirm the proposed level scheme of $^{183}$W. The recently discovered 313.28-keV transition has been inserted into the level scheme, and a new single particle state $9/2^+$ [624] at 622.7 keV is proposed. The isomeric level at 309.4 keV is shown to have spin and parity $11/2^+$. (auth)

**2724** ELECTROMAGNETIC TRANSITIONS IN ODD-A NON-AXIAL NUCLEI. Pashkevich, V. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 257-70(Feb. 1966). (In Russian).

Excited state energies, M1 and E2 transition probabilities, and Coulomb excitation probabilities were calculated on the basis of the generalization to the case of an odd nucleus with a nonaxial core of the theory of Davydov and Sardaryan in which adiabaticity of the collective motions with respect to the single-particle motions was not assumed. The calculations were undertaken because the transition probabilities are sensitive to angular momentum mixing, which is not taken into account in the model, and a comparison of such calculations with experiment could accordingly be expected to provide information concerning the limits of validity of the theory and indications of how it might be improved. The calculations are described in some detail. Numerical calculations were performed with the aid of a computer for nuclei with spins $5/2$ and $7/2$, and the results are presented graphically. The calculations show that a small change in the nonaxiality parameter can give rise to large changes in the structures of the levels. Calculated energy levels and transition probabilities are compared with experimental data from several sources on $^{165}$Ho, $^{165}$Dy, and $^{167}$Er. The calculated level energies are in good agreement with the experimental values for the band for which $|\Omega|$ has approximately the ground-state value, and for the $K \approx |\Omega| - 2$ band. For the $K \approx |\Omega| + 2$ band (observed only in $^{165}$Ho) the calculated energies are lower than the experimental values. It is concluded that in $^{165}$Ho, $^{165}$Dy, and $^{167}$Er, the lowest excited states with spins $3/2$, $5/2$, and $7/2$ belong to the anomalous rotation bands based on the ground states of the respective nuclei, but that better experimental data will be required to determine the position of the $K \approx |\Omega| + 2$ anomalous rotation band in $^{165}$Ho. (ATD)

**2725** DETERMINATION OF THE CAPTURE CROSS SECTIONS OF $^{156}$Gd FOR REACTOR NEUTRONS Lugmair, G.; Viehboeck, F. P. (Univ., Vienna. Reaktorzentrum, Seibersdorf, Austria). Acta Phys. Austr., 23: 64-9(1966). (In German).

The methods used for the determination of the effective cross section of isotopes are outlined, and the method used for the determination of the capture cross section of $^{156}$Gd (the mass spectrometric measurement of the isotope frequency before and after irradiation) is described in some detail. The method used for the determination of the integrated neutron flux is outlined. The capture cross section of $^{156}$Gd was measured as $\sigma = 8.67 \pm 0.43$ b. (J.S.R.)

**2726** REACTION CROSS SECTIONS ON $^{90}$Sr FOR REACTOR NEUTRONS. Zeisel, G. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 223(1966). (In German).

The presence of a neutron reaction on $^{90}$Sr in addition to the $(n,\gamma)$ reaction was investigated. $^{90}$Sr was converted into $^{90}$Y by the formation of an excited state which has accelerated $\beta$ decay. Measurements with two ionization chambers in a compensation circuit gave

an upper limit of 50 mb for this cross section. The cross section of the reaction $^{90}Sr(n,\gamma)^{91}Sr$ was determined as 0.8 ± 0.5 b. (J.S.R.)

**2727** INVESTIGATION OF THE 50-sec ACTIVITY PREVIOUSLY ASSIGNED TO $^{198}$Ir AND NEW DECAY SCHEME FOR $^{196}$Ir. Vonach, H. (Technische Hochschule, Munich); Muenzer, H.; Hille, P. Acta Phys. Austr., 23: 185-93(1966). (In German).

The activities formed in natural Pt and enriched $^{196}$Pt under bombardment with 14-MeV neutrons were investigated. The 50-sec activity previously assigned to the decay of $^{198}$Ir was assigned to the decay of $^{196}$Ir. The analysis of the $\beta$ and $\gamma$ spectra and analysis of the $\gamma$-$\gamma$ coincidence spectra gave a decay scheme with the following essential characteristics: The decay occurs principally to the ground state of $^{196}$Pt and the decay energy is 3.17 ± 0.06 MeV. Weaker $\beta$ components lead to excited states at 0.35, 0.80, and 1.12 MeV. The log ft values of the $\beta$ transitions correspond to the permitted or singly forbidden transitions and give spin 1 for the ground state of $^{196}$Ir. (tr-auth)

**2728** A SIMPLE METHOD FOR MEASUREMENT OF ISOMERIC NUCLEAR STATES IN THE HALF LIFE REGION OF 50 μs TO 1 ms. Scheimbauer, P.; Hille, P. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 229-31(1966). (In German).

The deuteron beam of a neutron generator was pulsed using a rotating slit disc with a pulse time of 50 μs and frequency of 400 Hz. Natural Hg was irradiated with 14-MeV neutrons produced in pulse operation. The 100 μs activity in $^{201}$Hg, produced previously only by photonuclear reactions, could be produced by the (n,2n) or (n,n′) reaction. (tr-auth)

**2729** NUCLEAR PHYSICS INVESTIGATIONS IN THE SEIBERSDORF REACTOR CENTER. Weinzierl, Peter (Technische Hochschule, Vienna). Acta Phys. Austr., 23: 312-25(1966). (In German).

A brief review is given of the nuclear physics investigations now in process or under preliminary study at the Seibersdorf Reactor Center. These include mass separator target preparations, shape factor measurements, neutron decay, measurement of neutron-capture $\gamma$ spectra, and study of the prompt $\gamma$ radiation in nuclear fission. (J.S.R.)

**2730** MOESSBAUER EFFECT OF $^{183}$W IN DIFFERENT W COMPOUNDS. Drosg, M.; Ujlaki, E. (Univ., Vienna). Acta Phys. Austr., 23: 47-50(1966). (In German).

The measurability of the Moessbauer effect of $^{183}$W was determined in W sheets, sodium tungstate, tungsten carbide, tungsten trioxide, and calcium tungstate at temperatures of liquid N and at room temperature. The results showed that the large Moessbauer effect of the 46.5-keV line of $^{183}$W is suitable for measurements without cooling and can also be used for the measurement of various physical properties of the material. (J.S.R.)

**2731** ASYMMETRY OF $^{235}$U PHOTOFISSION AS A FUNCTION OF THE MAXIMUM ENERGY OF BREMSTRAHLUNG. Kondrat'ko, M. Ya.; Petrzhak, K. A. At. Energ. (USSR), 20: 514-16(June 1966). (In Russian).

The ratio of fission products resulting from symmetric and asymmetric fission of $^{235}$U exposed to 10- to 25-MeV bremsstrahlung was investigated. The bremsstrahlung was generated by directing the electron beam on the container of the target and its tungsten sleeve. The maximum energy of the bremsstrahlung was checked by the electron phase shift between the injection phase and the incidence on the target, calibrating it on the basis of the known photoneutron reaction threshold values. The $^{235}$U oxide was applied on both sides of an aluminum foil, trapping the emitted fission products on aluminum collectors. Decay of the activity of the specimens was followed for 10 to 15 half lives of the isotope in question, $^{139}$Ba, $^{140}$Ba, $^{115}$Cd, and $^{117}$Cd, representing the products of both types of fission. The ratios of the yields of the barium isotopes and cadmium isotopes from the $^{235}U(\gamma,f)$ reaction were plotted for maximum energies from 10.0 to 25.2 MeV. The results indicated that the order of magnitude and the general course of the curves are similar to those reported for the yields of $^{91}$Sr and $^{115}$Cd resulting from the fission of $^{235}$U by 20-MeV bremsstrahlung and of $^{139}$Ba and $^{115}$Cd from the photofission of $^{238}$U. Thus, the "peak-and-valley" ratios of the two uranium isotopes exhibit great similarities as to their order of magnitude and their energy dependence. (TTT)

**2732** ANALYSIS OF THE FISSION CROSS SECTIONS OF $^{232}$Th, $^{233}$U, $^{234}$U, $^{235}$U, $^{236}$U, $^{237}$Np, $^{238}$U, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, AND $^{242}$Pu FROM 1 keV TO 10 MeV. Davey, William G. Nucl. Sci. Eng., 26: 149-69(1966).

The published cross sections of $^{232}$Th, $^{233}$U, $^{234}$U, $^{235}$U, $^{236}$U, $^{237}$Np, $^{238}$U, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, and $^{242}$Pu from 1 keV to 10 MeV were carefully studied to select the best cross sections for fast reactor analysis. Emphasis was placed on determining the reference data used; and, where necessary, the published data were revised to accord with more accurate, currently accepted cross sections. Thus, it is believed that a consistent set of cross-section data was derived. Some cross checks were made by comparing calculations based on the selected cross sections with integral measurements in broad fast-neutron spectra. The study shows the great importance of the $^{235}$U fission cross section in deriving other cross sections and emphasizes the necessity of re-evaluating nearly all fission cross sections, if it proves necessary to revise the $^{235}$U data. (auth)

**2733** EXCITATION FUNCTIONS FOR PROTON-INDUCED REACTIONS OF $^{140}$Ce AND $^{142}$Ce UP TO $E_p$ = 15 MeV. Furukawa, Michiaki (Tokyo Univ.). Nucl. Phys., 6701A: 253-60(1967).

Excitation functions for the reactions $^{140}Ce(p,n)^{140}Pr$, $^{140}Ce(p,2n)^{139}Pr$, and $^{142}Ce(p,n)^{142}Pr$ were measured by the activation method. The sum of the measured cross sections for $^{140}$Ce is compared with the theoretical total reaction cross section. Below 10 MeV the sum is reproduced by the theoretical values, when $r_0$ is assumed to be 1.5 fm. The measured cross sections for each reaction are compared with the predictions from the statistical theory of nuclear reactions by use of a level density expression of the form $W(E) = C \exp[4a(E-\delta)]^{\frac{1}{2}}$. The experimental cross sections and the theoretical values agree fairly well, when different values of a are applied to the different targets. (auth)

**2734** MAGNETIC MOMENTS OF $2^+$ STATES IN EVEN Te NUCLEI. Borchers, R. R. (Univ. of Wisconsin, Madison); Bronson, J. D.; Murnick, D. E.; Grodzins, L. Phys. Rev. Lett., 17: 1099-1102(Nov. 21, 1966).

The magnetic moments of the first $2^+$ states in the even Te nuclei were systematically investigated. The $g_R$ values obtained increase from 0.44 for $^{120}$Te to 0.93 for $^{128}$Te. Not only are these values in strong disagreement with theory but the higher values are also substantially greater than Z/A. (auth)

**2735** EXPERIMENTAL EXPLORATION OF THE LIMITS OF THE NILSSON MODEL; VIBRATIONAL STATES IN $^{177}$Hf AND $^{181}$Hf. Rickey, F. A. Jr.; Sheline, R. K. (Florida State Univ., Tallahassee). Phys. Rev. Lett., 17: 1057-60(Nov. 14, 1966).

Lack of specific Nilsson states with low K value for assignment of rotational bands observed in $^{177}$Hf and $^{181}$Hf between 1 and 2 MeV, together with cross-section measurements, suggest fragmentation of bands into a large number of vibrational components. It is suggested that the previously unobserved pairing vibrations, the $\beta$ vibrations, and the more common K-2 gamma vibrations may be responsible. (auth)

**2736** A GAMMA-RAY CASCADE MODEL FOR THE CALCULATION OF AVERAGE $\gamma$-RAY MULTIPLICITIES AND ISOMERIC CROSS SECTION RATIOS. Poenitz, W. P. (Kernforschungszentrums, Karlsruhe, Ger.). Z. Phys., 197: 262-75(1966).

The calculations of the $\gamma$-ray cascades following the decay of a compound state were carried out using all levels with known values of energy, spin, and parity at low energy and statistical assumptions for the distribution of the nuclear levels in the energy range between the initially occupied compound state and the low-lying levels. Dipole and quadrupole transitions were taken into account. The model works without the introduction of an artificial average transition energy. The model was applied to the calculation of average $\gamma$-ray multiplicities and of isomeric cross section ratios. The applications to the determination of level density parameters are discussed. It was shown that it is not allowed to neglect the contribution of quadrupole radiation in the cascade as was done in other models in the past. Only in the case of $^{115}In(n,\gamma)^{116}In$ enough data are available to determine statistical parameters. Values obtained for the level density parameter, the spin cut-off factor, and a contribution from quadrupole radiation in the cascade were a = 1.86 $MeV^{-1}$, $\sigma$ = 4.8, and 5%, respectively. (auth)

**2737** LEVELS IN $^{239}$U. Sheline, Raymond K. (Florida State Univ., Tallahassee); Shelton, W. Neil; Udagawa, Takeshi; Jurney, Edward T.; Motz, Henry T. Contract W-7405-eng-36. Phys. Rev., 151: 1011-22(Nov. 18, 1966). (LA-DC-7915).

Thirty-seven levels were observed in $^{239}$U up to an excitation energy of 1692 keV with 12-MeV deuterons and the reaction $^{238}U(d,p)^{239}U$. The ground-state Q value was determined as 2579 ± 7 keV. A germanium detector, operated as a pair spectrometer for high-energy capture gamma rays and as a total-energy anti-coincidence spectrometer for low-energy gamma rays, was used to measure 27 high-energy transitions between 3150 and 4850 keV and 27 low-energy transitions between 490 and 900 keV. Analysis of the combined data suggests fairly definite assignments for 13 states below 373 keV. The presence of the 152-neutron energy gap is clearly indicated by the absence of states between 373 and 692 keV. From 692 keV upward, nine additional tentative assignments are made. The spectroscopic assignments are [band-head energy

(keV) in parenthesis, followed by spin, parity, and (in brackets) asymptotic quantum numbers]: (ground state), $5/2$ + [622] with superimposed rotational band to $11/2$ + (133), $1/2$ + [631] with rotational band to $9/2$ +; (~173), $7/2$ + [624] with rotational band to $13/2$ +; (692), $1/2$ + [620] with rotational band to $5/2$ +, and (742), $1/2$ − [761] with anomalous rotational spacings to $11/2^-$. A table of $C_{i,l}$ values for deformation $\beta$ of 0.20, 0.25, and 0.30 is presented for all Nilsson orbitals of interest in the actinide region. The relative intensities or signatures of the bands are found for the most part to be in good agreement with theory. Absolute magnitudes are a factor of 2 too high. This discrepancy is ascribed to Coulomb stripping effects. (auth)

**2738** M1 TRANSITION PROBABILITIES IN THE ODD YTTERBIUM ISOTOPES $^{171}$Yb AND $^{173}$Yb. Palms, J. M.; Bernstein, E. M.; Seaman, G. G. (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-eng-36. Phys. Rev., 151: 1004-10 (Nov. 18, 1966). (LA-DC-8029).

Coulomb-excitation studies were performed on the ytterbium isotopes 171 and 173, using oxygen ions with energies up to 55 MeV. Resulting de-excitation gamma rays were observed in coincidence with back-scattered particles with a NaI(Tl) detector, and as singles spectra with a Ge(Li) detector. Gamma rays which are assigned to transitions within the ground-state rotational bands up to and including the $13/2$ level are as follows: $^{171}$Yb, 67.2, 76.4, 154.8, 164.0, 170.7, 240.0, 256.6, and 262.0 keV; $^{173}$Yb, 78.3, 100.3, 122.3, 143.7, 178.6, 222.5, and 265.9 keV. The following weak gamma rays were also observed: $^{171}$Yb, 85.0, 109.0, and 194.0 keV; $^{173}$Yb, 272.7, 286.0, and 637.0 keV. M1 transition rates between rotational states were determined from branching ratios, with the assumption that the rotational-model values for the relative E2 transition rates are correct. Agreement with the theory was found within the experimental error. For both nuclei a comparison was made between experimentally determined values for the parameters describing the intrinsic state and those calculated using the Nilsson wave functions. Excellent agreement is obtained if the spin gyromagnetic ratio for the free nucleon is replaced by an effective value $g_{S,\,eff}$. In the case of $^{171}$Yb, the agreement of three independent determinations of $g_{S,eff}$ appears to provide further evidence that the concept of replacing the free particle $g_S$ by an effective value is valid. (auth)

**2739** (p,t) REACTION ON THE ISOTOPES OF Sm AND Nd, N = 88 AND 90. Maxwell, J. R.; Reynolds, Glenn M.; Hintz, Norton M. (Univ. of Minnesota, Minneapolis). Phys. Rev., 151: 1000-3(Nov. 18, 1966).

The (p,t) reaction on targets of $^{148}$Nd, $^{150}$Nd, $^{150}$Sm, and $^{152}$Sm was investigated using a 40-MeV beam. Angular distributions were measured for the low-lying levels in the range 5 to 40°. These nuclei are interesting in that they have N = 88 and 90, and span the rather sharp transition from a region of spherical to deformed nuclei. Three equally strong L = 0 transitions are observed in the $^{152}$Sm(p,t)$^{150}$Sm spectrum corresponding to the excitation of $0^+$ states in $^{150}$Sm at 0, 0.78, and 1.28 ± 0.05 MeV. The L = 0 transition to a $0^+$ state at 1.28 MeV in $^{150}$Sm appears to correspond to the excitation of a deformed state in a nucleus with an approximately spherical ground state. One might expect the (p,t) reaction to excite such a state because the target nucleus, $^{152}$Sm, is deformed. The 0.78-MeV group in the $^{152}$Sm(p,t)$^{150}$Sm spectrum probably corresponds to the excitation of the known $0^+$, "two-phonon," state at 0.743 MeV. In the $^{150}$Sm(p,t)$^{148}$Sm reaction, where both the target and residual nuclei have spherical ground states, the ground-state L = 0 transition is the only state observed with significant strength below 1.45 MeV. A group at 1.45 MeV, which probably includes some L = 0 strength, is observed with about $1/3$ the strength of the ground-state transition. The $^{150}$Nd and $^{148}$Nd(p,t) spectra are similar to the two Sm spectra with the same neutron number. Comparison is made with the existing (t,p) data on the same Sm nuclei. (auth)

**2740** POSITRON DECAY OF $^{147}$Eu. Gromov, K. Ya.; Zhelev, Zh.; Kung, Hsiang-chin; Muziol, G.; Han, Shu-juan. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2239-42(Dec. 1965). (In Russian).

The $\beta^+$ decay of $^{147}$Eu to $^{147}$Sm was investigated. A triple-coincidence scintillation system was used to measure the coincidence of the 511−511 keV gamma quanta and the quanta of the entire gamma spectrum; peaks were found at 120 and 200 keV. The intensities of $\beta^+$ transitions to the ground state and the 121- and 198-keV levels of $^{147}$Sm were obtained. (D.C.W.)

**2741** POSITRONS IN $^{147}$Gd DECAY. Gromov, K. Ya.; Zhelev, Zh. T.; Kalinnikov, V. G.; Kuznetsov, V. V.; Kung, Hsiang-chin; Muziol, G.; Han, Shu-juan; Khalkin, V. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2235-8(Dec. 1965). (In Russian).

The positron emission of $^{147}$Gd is studied with a scintillation spectrometer and a triple-focussing beta spectrometer. The gadolinium sample was extracted from a tantalum target that had been irradiated for 2 hr at 660 MeV. The purpose of this work was to determine the $^{147}$Eu levels that are populated by positron decay of $^{147}$Gd. This is done by studying the triple coincidence of the 511-511 keV gamma quanta and the quanta of the entire gamma spectrum. Triple-coincidence spectra are plotted for two geometries of the detectors. The lone peak at 230 keV indicates that a large fraction of the positrons populates the 229-keV level. The remainder is shown to go to ground state. The schematic diagram of $^{147}$Gd → $^{147}$Eu is shown. (JPRS)

**2742** COULOMB EXCITATIONS OF LOWER LEVELS IN THE ISOTOPES $^{204,206,207}$Pb AND $^{209}$Bi. Andreev, D. S.; Gangrskii, Yu. P.; Lemberg, I. Kh.; Nabichvrishvili, V. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2231-4(Dec. 1965). (In Russian).

In order to determine the effective nucleon charge, it is especially important to know transition probabilities for nuclei having one nucleon (or one hole) above the filled shell. Accurate data on this problem are lacking because the Coulomb output of the excited levels of such nuclei are very small even when bombardment particle energies are very high. Nitrogen ions ($^{14}$N) were accelerated up to 66.5 MeV. Gamma quanta ejected forward from a Bi-enriched lead target were recorded. Nitrogen ions of 66.5-MeV energy were used to study the Coulomb excitation of $^{207}$Pb and Bi; and 63-MeV ions, for $^{204}$Pb and $^{206}$Pb. The values of B(E2) are adversely affected by inadequate correction for angular correlation, and though the error is not more than 25% for the 0.57-MeV level of $^{207}$Pb, it reaches 35 to 40% for the 0.89-MeV level of $^{207}$Pb and the 0.91-MeV level of $^{209}$Bi. The effective neutron charge is found to be close to unity, whereas that for the proton is unexpectedly large: 2.6 to 3.0. Speculations are advanced briefly on the effect of level excitation of giant resonance and effects of possible secondary processes. The general rule is drawn: for spherical even-even nuclei the farther the closed shell is from the nucleus, the lower is the energy of the first $2^+$ level and the greater is the value of B(Ez) for the transition to this level. But this rule does not hold completely for even isotopes of lead. (JPRS)

**2743** NEW DATA ON $^{135}$Ce DECAY. Balalaev, V. A.; Dzhelepov, B. S.; Medvedev, A. I.; Uchevatkin, I. F.; Shestopalova, S. A. (Mendeleev All-Union Scientific-Research Inst. of Metrology, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2205-24(Dec. 1965). (In Russian).

To verify the electron transitions of $^{135}$Ce having energies of 87 ± 1 and 120 ± 1 keV, the conversion-electron spectra of the isotope were investigated. The results were compared with other experimental observations; a systematic discrepancy in the energies was noted. Information on the relative gamma intensities, the multipolarity of $^{135}$La transitions, the photoelectron spectrum of $^{135}$Ce, the decay scheme of $^{135}$Ce, and coincidences among transitions between the excited states of $^{135}$La was obtained. (D.C.W.)

**2744** KINETIC ENERGIES OF FRAGMENTS FROM THE THERMAL NEUTRON FISSION OF $^{241}$Pu. Borukhovich, G. Z.; Petrov, G. A. (Ioffe Inst. of Physics and Tech., Leningrad). Yadern. Fiz., 4: 791-2(Oct. 1966). (In Russian).

The kinetic energies of fragments from the thermal neutron fission of $^{241}$Pu were measured using two surface-barrier counters with an area of 8 cm$^2$. The total energy for various mass ratios was determined with an accuracy of ±2 MeV. (auth)

**2745** COINCIDENCE OF CONVERSION ELECTRONS IN $^{135}$Ce DECAY. Dzhelepov, B. S.; Moskvin, L. N.; Tishkin, P. A.; Uchevatkin, I. F.; Shishelov, I. A. (Leningrad State Univ. Mendeleev All-Union Scientific Research Inst. of Metrology, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2264-70(Dec. 1965). (In Russian).

The scheme of excited levels of $^{135}$La was investigated. The spectrum of the conversion electrons was obtained with a duplexed toroidal beta spectrometer. The $^{135}$Ce sample was obtained from a tantalum target irradiated by 660-MeV protons for 5 to 10 hr. The results appear to be definitive for the locations of transitions with energies of 88.4 and 118.0 keV in the upper part of the decay scheme. (JPRS)

**2746** NEW DATA ON THE CONVERSION ELECTRON SPECTRA OF $^{140}$La. Balalaev, V. A.; Dzhelepov, B. S.; Medvedev, A. I.; Meshter, A.; Prikhodtseva, V. P.; Uchevatkin, I. F. (Mendeleev All-Union Scientific-Research Inst. of Metrology, USSR. Radium Inst., Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2250-4(Dec. 1965). (In Russian).

The conversion-electron spectrum of $^{140}$La at energies above 2.2 MeV was investigated. No lines were observed in the range from 2.53 to 2.83 MeV. The line K432 was found to differ from previous observations. No evidence of doublet structure of the line K1596 was observed. (D.C.W.)

**2747** SHORT-PERIOD ISOMERS $^{137m}$La, $^{172m}$Lu, AND $^{187m}$Ir. Gritsyna, V. T.; Klyucharev, A. P.; Remaev, V. V. Yadern. Fiz., 4: 678-82(Oct. 1966). (In Russian).

The results of the investigation of two new short-period isomers $^{137m}$La and $^{172m}$Lu and a previously found isomer, $^{187m}$Ir, are presented. The excited states of the lanthanum and lutetium nuclei were obtained in the irradiation of barium and ytterbium targets by protons. The isomer state $^{137m}$La decays with the half-life 12 ± 4 msec, emitting 230 ± 10 keV and approximately 450 keV γ-quanta. The half-life of the $^{172m}$Lu isomer is 450 ± 20 μsec and its γ-ray energy spectrum consists of lutetium x rays and a 68 ± 5 keV γ-transition. An additional γ-line with the energy 188 ± 5 keV was found in the γ-spectrum of the $^{187m}$Ir isomer. Decay schemes are suggested for all three isomers. The isomer state of the $^{137}$La nucleus should probably be interpreted as a three-particle one. Further, an isomer activity with the half-life 0.75 msec and γ-ray energies 180, 280 and approximately 400 keV was found in the irradiation of an $^{174}$Yb isotope target by fast protons. (auth)

**2748** THE α-DECAY OF $^{232}$U. Baranov, S. A.; Aliev, I. G.; Kulakov, V. M.; Shatinskii, V. M. Yadern. Fiz., 4: 673-7(Oct. 1966). (In Russian).

The α spectrum of $^{232}$U was investigated by means of a magnetic α spectrograph. Six α lines were observed in the spectrum of this uranium isotope, lying in the energy region $\Delta E_\alpha$ = (4925 to 5320) keV. The α-decay scheme of the $^{232}$U nucleus is given. (auth)

**2749** THE γ-SPECTRUM OF $^{106}$Rh. Ovechkin, V. V.; Ragimov, T. K.; Rau, D. F. Yadern. Fiz., 4: 683-5(Oct. 1966) (In Russian).

The γ spectrum of $^{106}$Rh was investigated in the region 0.5 to 3.5 MeV. The absolute outputs of the most intensive γ lines with energies of 0.513 and 0.624 MeV were found to be (21.0 ± 2.0) % and (10.0 ± 1.0) %, respectively, in agreement with the results of previous investigation. The relative γ-line outputs were determined: 1.55(0.81 ± 0.03); 1.77(0.26 ± 0.06); 1.96(0.14 ± 0.06); 2.10(0.15 ± 0.03); 2.44(0.19 ± 0.05); 2.66(0.040 ± 0.015); 2.87(0.025 ± 0.006) and 3.05(0.011 ± 0.003) MeV. The intensity of the 0.513 MeV γ-line was taken as 100; no 3.4 MeV γ line was detected. The features of the $^{106}$Rh decay scheme are discussed. (auth)

**2750** ON THE DECAY SCHEME OF $^{240}$Am. Bilibin, L. P.; Aurov, G.; Albov, A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 217-19(Feb. 1966). (In Russian).

The γ rays accompanying the K-capture decay of $^{240}$Am to $^{240}$Pu were investigated. The $^{240}$Am was obtained from the (d,n) reaction of $^{239}$Pu and was deposited on a Teflon substrate. The γ spectrum was recorded with scintillation spectrometers employing 4 cm × 4 cm and 8 cm × 5 cm NaI(Tl) crystals. The spectrometer employing the 4 cm × 4 cm crystal was calibrated with $^{241}$Am, $^{144}$Ce, $^{198}$Au, and $^{60}$Co sources, the absolute activities of which had been measured with a 4π β counter or an ionization chamber. Gamma rays ascribable to $^{240}$Am were observed at 100, 940, 1040, and 1400 keV. The 100-keV line is attributed to K x radiation. From the intensities of the different γ rays, it is concluded that of the electron capture decays of $^{240}$Am, some 20% go to the 940-keV level in $^{240}$Pu, 80% go to the 1040-keV level, and 0.1% go to the 1400-keV level. The 1400-keV gamma line was found to be considerably less intense than was reported elsewhere. The intensities of the other lines are in satisfactory agreement with the other findings. (ATD)

**2751** DELAYED GAMMA TRANSITIONS IN $^{186}$Re AND $^{188}$Re INDUCED IN NEUTRON CAPTURE REACTIONS. Berestovoi, A. M.; Kondurov, I. A.; Loginov, Yu. E. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 209-13(Feb. 1966). (In Russian).

Delayed gamma transitions were investigated, and lifetimes of excited states were measured in $^{186}$Re and $^{188}$Re. Small (50 mg) samples of metallic rhenium enriched in $^{185}$Re or $^{187}$Re were irradiated in the collimated thermal-neutron beam from a water-moderated reactor. The gamma rays from the irradiated samples were detected with two NaI:Tl scintillators connected into a fast-slow coincidence circuit. Half lives were measured with the aid of a time-to-pulse height converter. Five lines ranging in energy from 63 to 255 keV were detected in the 12-nanosec delayed γ spectrum of $^{186}$Re. The half life measured for this group of lines (of which the 63-keV line was by far the most intense) was 11.7 ± 1.2 nanosec. In the 10-nanosec delayed spectrum of $^{188}$Re, there were detected four lines ranging in energy from 62 to 205 keV. The 205-keV line did not appear in the 20-nanosec delayed spectrum, and its half life was found to be 4.6 ± 0.3 nanosec. The measured half life of the long-lived group of $^{188}$Re states was 7.7 ± 0.6 nanosec. The nature of the observed states is discussed and a level diagram for $^{188}$Re is presented. (ATD)

**2752** LIFETIME OF THE FIRST EXCITED STATE OF $^{149}$Sm. Berlovich, E. E.; Golovin, V. V.; Polyakov, A. G.; Khodshaev, M.; Khaidarov, T. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 194-7(Feb. 1966). (In Russian).

The lifetime of the 22.5-keV first excited state of $^{149}$Sm was measured. The source was obtained by bombarding terbium with 680-MeV protons for 5 hr and separating the europium fraction 5 mon later. $^{149}$Eu decays by electron capture to $^{149}$Sm: Delayed coincidences were recorded between the gamma rays from the 328-keV transition to the 22.5-keV level and conversion electrons from the decay of that level. The gamma rays were detected with an NaI crystal scintillator, and the conversion electrons, with a thin (0.5 mm) plate of anthracene. The half life of the 22.5-keV level was found to be 6.9 ± 0.5 × $10^{-9}$ sec. The nature of the low-lying levels of $^{149}$Sm is discussed. The description given by the phonon model of Kislinger and Sorensen (Rev. Mod. Phys., 35: 853(1963)) is favored, although that model predicts much too high a value for the quadrupole moment of the $^{149}$Sm ground state. From the reduced transition probabilities from the ground state to the different excited states, the root-mean-square deformation of $^{149}$Sm was calculated and was found to be 0.13. That value coincides with the corresponding value for the even-even $^{148}$Sm core (derived from the reduced probability for the $0^+ \rightarrow 2^+$ transition) and confirms the phonon nature of the low-lying $^{149}$Sm levels. (ATD)

**2753** SEARCH FOR TWO-QUANTUM PROCESSES IN THE DECAY OF $^{131m}$Xe. Knauf, K.; Sommer, H.; Klewe-Nebenius, H. (Univ., Heidelberg). Z. Phys., 197: 101-12(1966). (In German).

The decay of $^{131m}$Xe was investigated in order to detect nuclear double decay processes, in which the transition energy is distributed either between two γ quanta or between one γ quantum and one K-conversion electron or between two K-conversion electrons. By analyzing the emitted γ radiation in a two-dimensional way, an upper limit of 2.2 × $10^{-5}$ was derived for the ratio of the γγ- to γ-transition probability. An investigation of the γ spectrum in coincidence with K quanta yielded an upper limit of 3 × $10^{-3}$ for the rate of $e_K$ γ transitions relative to γ transitions. The simultaneous emission of two K quanta was actually observed. These double K quanta result either from the double K conversion that was sought or from the internal conversion of the internal Compton effect. For the double K-electron emission to γ-emission probability a value of (3.6 ± 0.7) × $10^{-3}$ was obtained. The K-conversion coefficient and the half life of $^{131m}$Xe were measured to be 32.1 ± 0.4 and 11.94 ± 0.04 d, respectively. (auth)

**2754** GAMMA SPECTRA OF NEUTRON-DEFICIENT Os AND Re ISOTOPES. Bedrosyan, P.; Bedike, T.; Dema, I.; Zaitseva, N. G.; Morozov, V. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 2225-30(Dec. 1965). (In Russian).

Gamma spectra of short-lived Os and Re isotopes were investigated in order to improve or correct existing data. The instruments employed were a 40 mm × 40 mm NaI crystal scintillation spectrometer with a resolution of 10% at 662 keV and a fast-slow gamma-gamma coincidence spectrometer with a resolving time of 10 nanosec. The source was the osmium fraction from a gold target bombarded for 30 min with 660-MeV protons. Rhenium was repeatedly separated from the osmium source to serve as the rhenium source. Analysis of the osmium decay curve showed the presence of activities with half lives of approximately 23 min, 90 min, and 23 hr. Gamma lines with half lives less than 2 hr were observed at 120, 190, 240, 310, 510, 800, and 880 keV. It was not in general possible to assign definite half lives to the different lines, but the decay of the intense 240-keV line was found to be complex with the two half lives: ~30 min and 90 ± min. A gamma spectrum recorded 14 hr after separation of the osmium showed lines at 115, 180, 385, and 510 keV. Gamma-gamma coincidence measurements were undertaken in the 510 keV region. No coincidences were observed at 90°, but coincidences were observed at 180°. The 510-keV line is accordingly ascribed to annihilation radiation. The decay of the annihilation radiation was complex, with half lives of 23 ± 3 min and 3 ± 0.5 hr. The rhenium separated from the osmium source 38 min after beginning of accumulation decayed with two half lives; 22 ± 3 min and 21 ± 2 hr. Associated with the short-lived activity there were observed gamma lines at 90, 135, 210, 260, 315, 440, 510, 600, 680, 760, 840, and 940 keV. Associated with the long-lived activity there was observed a gamma line at 365 keV; this activity is accordingly ascribed to $^{181}$Re. (ATD)

**2755** ANGULAR DISTRIBUTIONS OF $^{17}$N NUCLEI FROM THE THREE-NEUTRON TRANSFER REACTIONS. Pomorski, L.; Tys, J.; Volkov, V. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 23: 369-70(Nov. 7, 1966).

The angular distributions of $^{17}$N from the bombardment of Ta and Au with $^{14}$N ions were measured at $E_{c.m.}$($^{14}$N) = 87.2 and 97.5 MeV. The angular distribution for three-neutron transfer is compared with that for single-neutron transfer. (auth)

**2756** GYROMAGNETIC RATIOS OF THE FIRST EXCITED STATES IN $^{100}$Ru, $^{101}$Ru, $^{102}$Ru, AND $^{106}$Pd. Auerbach, K. (Univ., Hamburg); Siepe, K.; Wittkemper, J.; Koerner, H. J. Phys. Lett., 23: 367-9(Nov. 7, 1966).

Perturbed angular correlations were measured to determine the nuclear g factors of the first excited states in $^{100}$Ru(g = +0.55 ±

0.07), $^{101}$Ru(g = −0.207 ± 0.017), $^{102}$Ru(g = +0.44 ± 0.10), and $^{106}$Pd(g = +0.40 ± 0.04). (auth)

**2757** EXPERIMENTAL OBSERVATION OF THE COUPLING OF THE ANALOGOUS CHANNELS IN A (d,p) AND (d,n) REACTION. Moore, C. Fred; Watson, Charles E.; Zaidi, S. A. A.; Kent, James J.; Kulleck, James G. (Univ. of Texas, Austin). Phys. Rev. Lett., 17: 926-8(Oct. 24, 1966).

The isobaric analog states in $^{91}$Nb and $^{91}$Zr were excited using the $^{90}$Zr(d,n)$^{91}$Nb and $^{90}$Zr(d,p)$^{91}$Zr reactions. Evidence that the (d,p) and analogous (d,n) channels are strongly coupled was obtained. It was shown that analog states can be excited by the (d,n) reaction. (D.C.W.)

**2758** PERTURBED DIRECTIONAL CORRELATION IN $^{181}$Ta. Cannon, Theodore Wiles. Corvallis, Oreg., Oregon State Univ., 1966. 92p.

Thesis.

The effect of a static quadrupole interaction on the 133-482 keV gamma−gamma angular correlation in $^{181}$Ta was studied by the delayed-coincidence method. Using a source of $^{181}$Hf in polycrystalline hafnium metal, the anisotropy was measured as a function of the time between the formation and decay of the 482-keV state with a fast-slow coincidence spectrometer. The anisotropy as a function of time clearly revealed fluctuations arising from the reorientation of the nuclear spin due to coupling of the quadrupole moment of the 482 keV state with the electric field gradients of the crystals. The interaction strength evaluated on the basis of the theory for axially symmetric gradients was $\omega_0 = 299 \pm 8$ Mc/sec. Evidence for the presence of a rhombic (non-axially symmetric) electric interaction was observed in the departure of the results from the predictions for the axially symmetric case. The results are, however, in agreement with the theory for rhombic interactions if the electric field gradient in the hafnium crystals is assumed to have an asymmetry parameter $\eta = 0.30 \pm 0.03$, and in addition, if a normal frequency distribution of full width at half-maximum equal to 10% is used to describe the variation of the field gradient from site to site. Further, using the evidence from Coulomb excitation for the strong deformation of the tantalum nucleus, it was determined that the quadrupole moment of the 482 keV state is $Q = 2.53 \pm 0.10 \times 10^{-24}$ cm$^2$. This allows the calculation of the field gradient magnitudes in metallic hafnium which yields $V_{zz} = \pm 5.18 \pm 0.27 \times 10^{17}$ V/cm$^2$, $V_{yy} = \mp 3.37 \pm 0.19 \times 10^{17}$ V/cm$^2$, and $V_{xx} = \mp 1.81 \pm 0.25 \times 10^{17}$ V/cm$^2$. The effect of a combined magnetic dipole and electric quadrupole interaction was also studied for the 133-482 keV correlation using external fields of 4.8 kilogauss and 8.3 kilogauss applied perpendicular to the plane of the detectors. Agreement with the theory for the case of mixed interactions was attained by assuming values of $y = 6\omega_H/\omega_0$ corresponding to the values of applied magnetic field, as well as an asymmetry parameter for the electric field gradient of 0.30 and a gaussian distribution of 10% width as in the zero field case. It is concluded that it is very difficult to measure nuclear magnetic moments by delayed differential angular correlation methods in solid sources with electric quadrupole and magnetic dipole interactions of the same order of magnitude if an appreciable distribution in quadrupole interaction frequencies exists within the sample. (Dissertation Abstr.)

## Nuclear Theory

*Refer also to abstracts 2397, 2603, 2606, 2627, 2666, 2695, 2696, 2717, 2720, 2721, and 2724.*

**2759** CALCULATION OF THE ANGULAR DISTRIBUTION OF NUCLEAR PARTICLES FROM MULTIPLE SCATTERING IN THIN FILMS. Breunlich, W. H. (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 364-8(1966). (In German).

Formulas for the calculations of the angular distribution of nuclear particles after multiple scattering in thin films are derived. The scattering distributions for whole number values of $\Omega_0$ between 1 and 20 are calculated using the shielding function. (J.S.R.)

**2760** ANGULAR CORRELATIONS WITH PARITY MIXING OF NUCLEAR STATES. Thirring, Walter (Univ., Vienna). Acta Phys. Austr., 23: 13-17(1966). (In German).

In order to explain experimental studies on parity mixing of nuclear states, the angular distribution of $\alpha$ radiation with spin 0, $\beta$ radiation with spin $\frac{1}{2}$, and $\gamma$ radiation with spin 1 is reviewed. It is concluded that $\gamma-\gamma$ cascades are not suitable for the study of parity mixing. (J.S.R.)

**2761** INTERNAL CONVERSION OF GAMMA TRANSITIONS AND ITS SIGNIFICANCE FOR NUCLEAR STRUCTURE STUDIES. Warhanek, Hans (Institut fuer Radiumforschung und Kernphysik, Vienna). Acta Phys. Austr., 23: 20-30(1966). (In German).

The expression describing the internal conversion of $\gamma$ transitions is given, and the discrepancy between theoretical and experimental values is discussed. The E0 transition and the electrical transition with angular momentum 0 are considered in some detail, and it is shown that the E0 operator is a pure radial operator. (J.S.R.)

**2762** ANGULAR DISTRIBUTIONS FROM NUCLEAR REACTIONS. Hittmair, O. Acta Phys. Austr., 23: 326-36(1966). (In German).

The angular distributions from nuclear reactions were calculated on the basis of the conservation of angular momentum. The various preparation and measurement processes that occur were formulated by quantum theory. A particle conservation state description in the $\gamma$ cascade is given. The formulas are applied to various forms of reaction mechanisms such as intermediate nuclear formation and direct reactions. (J.S.R.)

**2763** $^{210}$Pb SHELL-MODEL CALCULATIONS WITH HARMONIC OSCILLATOR WAVE FUNCTIONS. Hertenberger, Gerhard (TGM, Vienna); Steinbach, Gerda; Geramb, Heinrich Viktor. Acta Phys. Austr., 23: 337-42(1966). (In German).

The dependence of the energy level splitting for 0+, 2+, 4+, and 6+ states on the extent of the configuration mixing, the potential form, and the potential parameter for singlet and triplet potential depth is shown. (tr-auth)

**2764** INVESTIGATION OF PARITY MIXING IN EXCITED NUCLEAR STATES FROM MEASUREMENT OF BETA-GAMMA ANGULAR CORRELATION. Dydak, F.; Woda, H. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 204-8(1966). (In German).

An excited nuclear state contains a small admixture of reverse parity so that in $\gamma$ transitions an interference occurs between both transition types of the same multipolarity, for instance E2 + M2. This can be observed in a $\beta-\gamma$ angular correlation experiment as forward-backward asymmetry (the expected deviation from spherical symmetry in the $^{41}$Ar and $^{203}$Hg nuclei amounts to approximately $10^{-3}$) with respect to the $\beta$ particles. The measurement is made with two $\beta$ and two $\gamma$ detectors at 0 and 180°. The simultaneous measurement of all coincidence counting rates was carried out with a 100-MHz time amplitude converter. (tr-auth)

**2765** DEUTERON BREAKUP IN INTERACTIONS WITH NUCLEI. Levshin, E. B. (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 367-70 (Feb. 1966). (In Russian).

The optical model is used to calculate the differential cross section for the (d,np) reaction without excitation of the final nucleus in the plane-wave Born approximation with the assumption of short range ($\delta$-function) neutron-proton forces. A simple closed expression in terms of elementary functions is obtained for the cross section. Curves are presented showing the energy distributions of the emitted protons for several different proton and neutron emission angles and the angular distributions of the neutrons for several different proton emission angles in the (d,np) reactions of 26-MeV deuterons on $^{197}$Au and 13.6-MeV deuterons on $^{60}$Ni. From a brief discussion of these curves in connection with other experimental data it is concluded that the plane-wave approximation correctly gives the qualitative behavior of the cross section but can not account for the positions and heights of the maxima. (ATD)

**2766** EFFECT OF CORRELATIONS IN THE GROUND STATE ON NUCLEAR REACTIONS. Zhivopistsev, F. A.; Yudin, N. P. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30 312-18 (Feb. 1966). (In Russian).

The effect on nuclear reactions of correlations in the ground state (backward Feynman diagrams) are discussed, particularly with regard to the excitation of 1$^-$, T = 1 or 3$^-$, T = 0 vibrational levels. The calculations are based on the Lippman-Schwinger formalism and the Green's function treatment of the nuclear many-body problem as presented by Klein and Zemach (Phys. Rev., 108: 126 (1957)). Formulas are written for the T-matrix elements for the (p,p′), (d,p), and (d,pc) reactions (here c indicates excitation of a vibrational level of the final nucleus) in terms of the corresponding wave functions and vertex functions. An expression including the effect of ground-state correlations is derived for the Fourier transform of the product of two single-particle Green's functions, with the aid of which the two-particle Green's function can be calculated. The three-particle Green's function, required to calculate the matrix element for the (d,pc) reaction, is calculated in the pole approximation from the two-particle Green's function. The matrix elements for the reactions, calculated with and without taking into account the ground-state correlations, are compared; and it is concluded that the contribution of backward Feynman diagrams is particularly important in the case of excitation of particle-hole type collective states, especially of 3$^-$, T = 0 states in light nuclei and 1$^-$ states in heavy nuclei. An advantage claimed

for the technique presented is that it enables one to judge the relative importance of the ground-state correlations without performing detailed numerical computations. (ATD)

**2767** INFLUENCE OF SEMITRANSPARENCY AND DIFFUSENESS OF THE NUCLEAR BOUNDARY ON ANGULAR DISTRIBUTIONS IN PARTICLE SCATTERING. Ismatov, E. [Inst. of Physics, Academy of Sciences, Ukrainian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 331-6(Feb. 1966). (In Russian).

The differential cross section for diffraction scattering of a particle by a semitransparent deformed nucleus with a diffuse boundary is calculated, and the results are compared with experimental data from different sources. Both the elastic scattering cross section and the cross section for inelastic scattering with excitation of a vibrational level of the scattering nucleus are calculated. The opacity is assumed to be constant within the scattering nucleus and to decrease exponentially with increasing distance from its surface. The theoretical formulas are compared with experimental data on elastic scattering of 27.2-MeV $\alpha$ particles on $^{48}$Ti and $^{27}$Al, of 44-MeV $\alpha$ particles on $^{58}$Ni, and of 19.6- and 21-MeV deuterons on $^{24}$Mg, and on inelastic scattering of 44-MeV $\alpha$ particles on $^{58}$Ni with excitation of the 1.45-MeV $2^+$ level and of 19.6- and 21-MeV deuterons on $^{24}$Mg with excitation of the 1.37-MeV $2^+$ level. The model parameters (nuclear radius, opacity, boundary diffuseness, and deformation parameter) were selected in each case to fit the theoretical curves to the experimental scattering data. Good fits were achieved. Taking the boundary diffuseness into account did not remove the gaps, characteristic of the diffraction model with a sharp nuclear surface, at the angular distribution minima for $\alpha$ particle scattering, but it did affect the magnitude of the cross section at the maxima. (ATD)

**2768** CALCULATION OF TENSOR FORCES IN THE THREE-NUCLEON PROBLEM. Sitenko, A. G.; Kharchenko, V. F. (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 328-30(Feb. 1966). (In Russian).

The three-nucleon problem was previously treated with the assumption of nonlocal central two-body forces. The previous calculations are extended with the aid of the potential of Yamaguchi and Yamaguchi (Phys. Rev., 95: 1635 (1954)) to take tensor forces into account. The calculation of the zero-momentum neutron-deuteron scattering length and the triton binding energy is reduced in the case of tensor forces, as previously in the case of central forces, to the solution of a set of linear integral equations. The integral equations were solved numerically, using values of the parameters in the expression for the Yamaguchi potential derived by Yamaguchi himself from low-energy two-nucleon interactions. The resulting 9.8-MeV theoretical triton binding energy is in much better agreement with the 8.48-MeV experimental value than is the 12.05-MeV binding energy previously calculated with central forces. The doublet scattering length calculated with tensor forces is also in better agreement with experiment than is the value previously obtained with central forces. The quartet scattering length calculated with central forces was already in good agreement with experiment, and no tensor force value for it is given. (ATD)

**2769** QUASI-SPIN FORMALISM AND MATRIX ELEMENTS IN THE SHELL MODEL. Arima, Akito; Ichimura, Munetake (Tokyo Univ. Nihon Univ., Tokyo). Progr. Theoret. Phys. (Kyoto), 36: 296-312(Aug. 1966).

The quasi-spin formalism is used to derive useful reduction formulas for the shell-model matrix elements for two-body scalar interactions between states having the same seniority quantum number. Several convenient reduction formulae are also derived in mixed configurations for both degenerate and nondegenerate cases. The seniority-violating component in the Wigner interaction is estimated, and its range dependence is investigated. (auth)

**2770** THEORY OF HINDERED NUCLEAR MATRIX ELEMENTS. Fujita, Jun-Ichi; Ikeda, Kiyomi (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 36: 288-95(Aug. 1966).

A method is given of obtaining a theoretical estimate for the hindered transition matrix element with better accuracy than in the conventional configuration-mixing treatment. Full advantage is taken of the commutation relation of the nuclear Hamiltonian and the relevant transition operator. (auth)

**2771** ON TAKING INTO ACCOUNT SPIN-DEPENDENT EFFECTS IN QUASI-ELASTIC KNOCKOUT REACTIONS. Zelenskaya, N. S.; Smirnov, Yu. F. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 278-84(Feb. 1966). (In Russian).

Some impulse-approximation calculations of the cross section of the quasi-elastic knockout reaction (a, ax) were generalized to take into account the spin-dependent terms in the interaction between the incident particle a and the knocked out particle or cluster x. The tensor forces between a and x are neglected; but the central forces, the spin-orbit coupling, and the spin-spin interaction are taken into account. The spin-dependent factor in the expression for the cross section is simplified for the case in which the spin of the incident particle a is $\frac{1}{2}$, and expressions are given for the cross section and for the polarizations of the scattered particle a and the knocked out cluster x (in the impulse approximation the recoil nucleus is not polarized. When the spin of the knocked-out cluster x is 0 or $\frac{1}{2}$ the correction to the cross section (with the tensor forces neglected) is rigorously zero. Computations for specific cases, in particular for the $^6$Li(p,pd) reaction, showed that the spin corrections to the cross section are small and that formulas derived without taking spin into account are adequate. It is suggested that measurements of the polarizations of knockout reaction products might provide information on the structure of the target nucleus and that measurements of the polarization of the recoil nucleus might give an indication as to the limits of validity of the impulse approximation. (ATD)

**2772** THEORY OF TWO NUCLEON TRANSFER REACTIONS: (t,p) AND (p,t) REACTIONS. Lin, Ching Liang (Tokyo Univ. Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 36: 251-87(Aug. 1966).

On the basis of the current theory of nuclear structure, calculated the (t,p) and (p,t) reaction cross sections for medium-weight nuclei with even Z and N were calculated. In the nuclear wave functions the pairing correlation is taken into account by using a BCS-type function, and the quadrupole-quadrupole forces are also considered in the random phase approximation where the quadrupole vibrational states are concerned. The cross section is given in a form suitable for the DWBA calculation. The zero-range approximation and harmonic oscillator wave function for all bound-state wave functions are still adopted. The results obtained are compared with experiment for $^A$Cd(p,t)$^{A-2}$Cd, $^A$Sn(p,t)$^{A-2}$Sn, $^{116}$Cd (t,p)$^{112}$Cd, $^{96}$Zr(p,t)$^{94}$Zr, $^A$Fe(p,t)$^{A-2}$Fe and $^A$Ni(p,t)$^{A-2}$Ni. Good agreement is obtained for lower incident energies, while the agreement is not so good for higher incident energies. (auth)

**2773** STATIC THEORY OF THE GIANT QUADRUPOLE RESONANCE IN DEFORMED NUCLEI. Danos, Michael (National Bureau of Standards, Washington, D. C.); Greiner, Walter; Kohr, C. Byron. Phys. Rev., 151: 761-72(Nov. 18, 1966).

The modes and frequencies of the giant quadrupole resonance of heavy deformed nuclei were calculated. The quadrupole operator is calculated, and the absorption cross section is derived. The quadrupole sum rule is discussed, and the relevant oscillator strengths are evaluated for various orientations of the nucleus. The giant quadrupole resonances have energies between 20 and 25 MeV. The total absorption cross section is about 20% of the giant dipole absorption cross section. Of particular interest is the occurrence of the quadrupole mode which is sensitive to the nuclear radius in a direction of approximately $\theta = \frac{1}{4}\pi$ from the symmetry axis. This may give information on the details of the nuclear shape. (auth)

**2774** METHOD OF COLLECTIVE VARIABLES IN NUCLEAR THEORY. Khokhlov, Yu. K. (Lebedev Inst. of Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 242-8(Feb. 1966). (In Russian).

A technique for introducing collective coordinates in the treatment of a many-body problem is outlined. The technique consists in introducing the collective coordinates as parameters in a suitable linear transformation of the Cartesian coordinate system and imposing appropriate conditions on the transformed coordinates in order to determine the parameters as functions of the Cartesian coordinates of the particles. The method is illustrated by the introduction of Euler's angles and the two deformation parameters as collective coordinates in the treatment of the rotations and vibrations of a deformed nucleus. Expressions are obtained for the collective momenta, and the Hamiltonian is separated into collective and internal terms. The interaction between the internal and collective motions is represented by the presence in the theory of internal collective momenta and by the dependence of the internal Hamiltonian on the collective coordinates as parameters. Villars calculate the interactions in specific cases either by a canonical transformation method or by nonstationary adiabatic perturbation theory. A third method, consisting of a generalization of stationary adiabatic perturbation theory, is presented and is illustrated by calculating the second-order interaction terms in the theory of a rotating but not vibrating deformed nucleus. (ATD)

**2775** CALCULATION OF DIRECT NUCLEAR REACTIONS BY THE DISTORTED WAVE METHOD. Gridnev, K. A.; Krasnov, L. V.; Kukhtina, I. N.; Luk'yanov, V. K.; Nikitina, V. I.; Furman, V. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 255-6(Feb. 1966). (In Russian).

Differential cross sections for (d,p) reactions were calculated in the distorted-wave approximation under the following simplifying assumptions: the range of the nuclear forces is zero (the in-

teraction potential is a delta-function), and there is no spin-orbit coupling. The calculated angular distribution of protons from the $^{56}Fe(d,p)^{57}Fe$ reaction with an incident deuteron energy of 6.6 MeV is compared with the angular distribution calculated in the plane-wave approximation (Butler's theory) and with experimental data. The experimental data are in much better agreement with the distorted-wave calculations than with the plane-wave calculations. (ATD)

**2776** THE EFFECT OF THE D-STATE OF THE DEUTERON IN (d,p) AND (p,d) REACTIONS. Johnson, R. C. (Univ. of Surrey, London). Nucl. Phys., 6701A: 289-310(1967).

The effect of the D-state of the deuteron in (d,p) and (p,d) reactions is discussed within the framework of the distorted-wave Born approximation. Numerical estimates with plane waves are used to suggest that the D-state may play an important role in certain reactions. The necessary modifications of previous work on polarization effects in the distorted-wave theory are discussed in detail. (auth)

**2777** DELBRUECK SCATTERING EFFECT IN THE COHERENT SCATTERING OF 2.62-MeV GAMMA RAYS. Nath, A. (Bose Inst., Calcutta). Sci. Cult. (Calcutta), 32: 308-11(June 1966).

The total coherent scattering (including the Delbrück component) of gamma radiation at 2.62 MeV was calculated for Pb as the scatterer. Values were obtained for polarizations and cross sections for scattering angles in the range $20° \leq \theta \leq 180°$, and results were compared with the corresponding values without Delbrück scattering. Inclusion of Delbrück scattering changes the polarization parameter by a large factor, while the cross section values with and without Delbrück scattering differ by 20 to 50% at most. It is suggested that polarization measurements, rather than conventional measurements of cross sections of coherent scattering of 2.62 MeV gamma rays, may be the decisive test for Delbrück scattering in the low energy range. (S.F.L.)

**2778** FOUR-PARTICLE CORRELATIONS IN LIGHT NUCLEI. II. Bremond, B. (Univ., Paris, Orsay, France). Nucl. Phys., 6701A: 241-52(1967).

The problem of two protons and two neutrons in an open shell with either pairing or contact interactions is studied. It is found that these interactions, which were equivalent for the two-neutron case, are no longer equivalent, contact interactions being stronger in four-particle configurations. The nucleus $^{32}S$, which is considered to be formed of two clusters of four holes of the most general form, is then studied. (auth)

**2779** DISPLACEMENT OF CORRESPONDING ENERGY LEVELS IN MIRROR NUCLEI. Lebon, G. (Univ., Liege). Mem. Soc. Roy. Sci. Liege, 13: No. 4, 1-125(1966). (In French).

The effects contributing to the displacement of the corresponding energy levels in mirror nuclei are studied; resonance levels are considered in detail using perturbation methods. A general perturbation method is developed and is applied to light mirror nuclei. (D.C.W.)

**2780** OPTICAL MODEL AND REGGE REPRESENTATION. Hoegaasen, J. (CERN, Geneva). Nucl. Phys., 6701A: 261-88 (1967).

The Regge representation for the elastic scattering amplitude is used to describe the differential cross sections of strongly absorbed projectiles. Apart from the small angles, it leads to very simple but nevertheless accurate expressions. Thus it is shown that the characteristic oscillatory diffraction pattern is very well reproduced by two poles in the complex l-plane not too close to the real axis and on each side of it. With more specification (definite relations between the residues and the poles), these two poles provide a good approximation for the classical three-parameter modified cut-off model of the Wood-Saxon (or Fermi) type. The model is applied to the case of 18- and 44-MeV alpha scattering on $^{40}Ar$ and $^{208}Pb$. It is also shown that the large-angle diffraction pattern can not always be described by one pole, as would follow from a resonance type of explanation. On the other hand, phase shifts are poorly reproduced by the model, a trouble related to the non-validity of the representation in the forward direction. A brief discussion is given of the significance of the results in terms of optical potentials, and different lines for further research are sketched. (auth)

**2781** IMPROVED SUPERFLUID CORRECTIONS TO THE $\beta$-DECAY PROBABILITIES OF DEFORMED NUCLEI. Bencze, Gy.; Sandulescu, A. (Univ. of Helsinki). Ann. Acad. Sci. Fenn., Ser. A VI, No. 209, 1-13(1966).

The superfluid model, with BCS and PBCS (projected BCS) wave functions, gives correction factors $R_{BCS}$ and $R_{PBCS}$ to the single-particle $\beta$-transition probabilities. These corrections are calculated for odd deformed nuclei in the transuranium region. The effect of particle-number conservation is greatest for the ground state-to-ground state $\beta$ transitions conserving the number of pairs, and for $\beta$ transitions between the ground state of an even system and the third excited state of an odd system when the number of pairs is changed. In the first case $R_{PBCS}$ is $\approx 10\%$ greater, and in the second case $\approx 13-14\%$ smaller than the corresponding BCS values. (auth)

**2782** NEUTRON CAPTURE IN (d,p) STRIPPING REACTIONS. Pearson, C. A. (Australian Atomic Energy Commission, Lucas Heights. Niels Bohr Inst., Copenhagen); Coz, M. Ann. Phys. (N. Y.), 39: 199-215(Sept. 1966).

It is shown that in (d,p) stripping reactions the proton is scattered as if the neutron were not present. The neutron is captured by a nonspherical potential. In the capture process the residual nucleus is polarized. The angular distributions for (d,p) reactions which leave the neutron in the $^3/_2^-$,$^1/_2^-$ states, respectively, are compared. It is predicted that when these angular distributions are appropriately normalized, their difference should have the sign of the polarization in elastic proton scattering. This result is experimentally observed. (auth)

**2783** MODEL OF THE OPTICAL MODEL. Austern, N. (Univ. of Pittsburgh); Prakash, A.; Drisko, R. M. Ann. Phys. (N. Y.), 39: 253-79(Sept. 1966).

An approximate parameterization of an exact expression for the reflection coefficient $\eta_l$, that describes elastic scattering by a spin-independent complex potential, yields a parameterized-phase-shift model of elastic scattering. The parameterization is based on a detailed study of the role played by the nuclear surface region; the nuclear interior is regarded as a region of uniform complex potential. Surface and volume effects are represented by distinct parameters. In all, nine parameters are used. These include the depths of the real and imaginary potentials in the interior, the radius at which the interior and exterior regions join, and six surface parameters that modify the effects caused by the interior region. These nine parameters describe the same physics as an optical potential that includes an arbitrary mixture of surface and volume interactions. The usual results of the strong-absorption case are derived by suitable specialization of the model. A numerical example that illustrates the application of the full model is given. (auth)

**2784** SEMICLASSICAL THEORY OF POLARIZATION AND CORRELATION IN DIRECT NUCLEAR REACTIONS. Abul-Magd, A. Y.; El-Nadi, M. (Atomic Energy Establishment, Cairo). Ann. Phys. (N. Y.), 39: 237-52(Sept. 1966).

The semiclassical approach to the correlation theory, as developed by Biedenharn, is applied to the calculation of the angular correlations and the spin-tensors characterizing the polarization of emitted particles and residual nuclei in direct nuclear reactions. The cross section of direct nuclear reactions produced by polarized particles and oriented nuclei is calculated. The formulas obtained are in agreement with the corresponding formulas derived quantum mechanically. (auth)

**2785** COMPETITION BETWEEN E2 AND M1 GAMMA TRANSITIONS IN NUCLEI OF HIGH SPIN. Sperber, Daniel (Illinois Inst. of Tech., Chicago). Contract AT(11-1)-578. Phys. Rev., 151: 788-91(Nov. 18, 1966). (IITRI-578-P25-17).

The effect of the competition between M1 and E2 electromagnetic transitions on the angular distribution of gamma rays from nuclei with high spin was studied. The angular distribution of such gamma rays was calculated as a function of their energy. This energy dependence of the angular distribution can be used to test the assumption that nuclei with high spin rotate as a whole. (auth)

**2786** COMPREHENSIVE FORMALISM FOR NUCLEAR REACTION PROBLEMS. I. DERIVATION OF EXISTING REACTION THEORIES. Lane, A. M. (Atomic Energy Research Establishment, Harwell, Eng.); Robson, D. Phys. Rev., 151: 774-87 (Nov. 18, 1966).

An attempt is made to reduce the confusion arising from the existence of many different theories of resonance reactions. The method is to set up a formalism which is sufficiently general so that individual theories may be obtained by appropriate specialization. Such a formalism is obtained by suitably generalizing that devised by Bloch for a smaller range of theories. The formalism facilitates comparison of the structure of the various theories. (auth)

**2787** IMPROVED SOLUTION TO THE BETHE–FADDEEV EQUATIONS. Day, Ben (Argonne National Lab., Ill.). Phys. Rev., 151: 826-9(Nov. 18, 1966).

An approximate analytic solution is derived for the Bethe–Faddeev three-body equations in nuclear matter. The solution is no more complicated than the original approximation proposed by Bethe, but it is more accurate and avoids the discontinuities

that appear in the original solution. In a certain limiting case, the solution agrees with the one previously proposed by Moszkowski on the basis of a variational treatment. (auth)

**2788** GAMMA-RAY YIELDS FROM NUCLEAR REACTIONS AND LEVEL DENSITIES OF DEFORMED NUCLEI. Rasmussen, J. O.; Sugihara, T. T. (Univ. of California, Berkeley). Phys. Rev., 151: 992-9(Nov. 18, 1966).

Theoretical calculations of spin distributions of compound nuclei and subsequent neutron-evaporation products are made for 27-MeV alpha particles on $^{178}$Hf, 52-MeV alpha particles on $^{180}$Hf, and 56-MeV $^{11}$B ions on $^{165}$Ho. The first two cases were chosen to match experimental work of Lark and Morinaga. The calculations are used as a basis for interpretation of their relative yield of $^{180m}$W, the $J = 8^-$ isomer, and the $J = 4^+$ state of the ground rotational band. It is found that the yields are consistent with the simple assumption that after the last neutron is evaporated to form the excited $^{180}$W nucleus all products with spin $J \gtrsim 10$ feed into the $8^-$ isomer and those with spin $J \lesssim 10$ contribute to the prompt radiation from the first $J = 4^+$ level. Possible relations between the course of the gamma cascade and the nature of the Nilsson orbitals nearest the Fermi surface are discussed. Finally, the importance of measuring gamma angular distributions in addition to integrated yields is stressed, and formulas of possible value for the analysis of such angular distributions are presented. (auth)

**2789** CONVENIENT ANALYTIC FORM FOR THE DEUTERON WAVE FUNCTION. McGee, Ian J. (Univ. of Wisconsin, Madison). Contract AT(11-1)-881. Phys. Rev., 151: 772-4(Nov. 18, 1966). (COO-881-69).

A convenient analytical form for the deuteron wave function is presented which reproduces the static properties of the deuteron and is in accord with numerical wave functions which fit neutron-proton scattering data up to 300 MeV. (auth)

**2790** SIMPLE FORMULA FOR QUASI-ELASTIC ELECTRON SCATTERING. Henry, G. Reading (Harvard Univ., Cambridge, Mass.). Contract AT(30-1)2752. Phys. Rev., 151: 875-8(Nov. 18, 1966).

An approximate analytic formula is developed for high-energy (several GeV or higher) quasi-elastic electron scattering from a complex nucleus, on the basis of a simple nuclear model. The approximation should be good enough to be useful in estimating experimental counting rates and backgrounds. For scattering at an angle $\theta$, the quasi-elastic peak is centered, in this approximation, at the energy $\epsilon_0 = \epsilon/[1 + 2(\epsilon/M) \times \sin^2(\frac{1}{2}\theta)]$, where $\epsilon$ is the incident energy and M is the nucleon mass. The peak has a full width at half maximum of about $\sqrt{2}\,(\epsilon_0^3/\epsilon)v_+[1+(1+\epsilon/M)^2\tan^2(\frac{1}{2}\theta)]^{\frac{1}{2}}\sin\theta$, where $v_+$ is a characteristic nucleon velocity in the nucleus, $v_+ \approx 0.28$. Inelastic electron scattering from complex nuclei is briefly discussed. (auth)

**2791** DEUTERON STRIPPING ON DEFORMED NUCLEI. Iano, P. J. (Univ. of Pittsburgh. Western Reserve Univ., Cleveland); Austern, N. Phys. Rev., 151: 853-74(Nov. 18, 1966).

Interference of indirect transition amplitudes with the direct transition amplitude for deuteron stripping on deformed nuclei is investigated. The indirect transitions that are considered are those that arise via intermediate rotational excitations of the target and product nuclei. These indirect transitions are introduced by generalizing the initial and final distorted waves so that they include inelastic amplitudes. A straightforward coupled-channel treatment of the generalized distorted waves is described. However, a quantitative investigation of the coupled-channel formulation is not attempted because of the enormous numerical difficulties that such a procedure would present. Instead, the rotational motion of the target is treated adiabatically; thereby, in principle, inelastic amplitudes in all rotational channels are accounted for simultaneously. Further simplification is achieved by treating the coupling of the rotational coordinates to the projectile coordinates only to first order. Calculations are performed for deuteron stripping on $^{24}$Mg and $^{238}$U. The calculations indicate that: the indirect amplitudes are small; the indirect amplitudes are affected more strongly by intermediate excitations in the deuteron channel than by intermediate excitations in the proton channel; the indirect amplitudes generally flatten the angular distributions of the reaction protons; and the ratio of the strength of the indirect transitions to that of the direct transition is fairly independent of the mass of the target. Although the spin-orbit force is neglected, the theory predicts a J dependence in the angular distributions that is significant at all angles. The indirect stripping amplitudes are small; however, they produce measurable effects in the differential cross section when they add coherently to the direct amplitude. The most dramatic effects of the indirect amplitudes are changes of the angular distributions of the reaction protons. In addition, the calculated spectroscopic coefficients are changed by a significant amount when the indirect amplitudes are taken into account. (auth)

**2792** MONOPOLE EXCITATION CORRECTIONS TO ELECTRON ELASTIC SCATTERING. Rawitscher, G. H. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Phys. Rev., 151: 846-52(Nov. 18, 1966).

The effect of the virtual excitation of nuclear levels on the electron elastic scattering cross section is calculated by means of a phase-shift analysis method under the assumption that the inelastic excitation is represented by a single monopole transition and that the nuclear excitation energy can be neglected. The formulas are applied to the case of 250-MeV electrons and positrons incident on the nucleus of Ca. Effects of the order of 5% are found in the vicinity of the first diffraction minimum. (auth)

**2793** VERTEX PARTS OF DIRECT NUCLEAR REACTION DIAGRAMS IN A POTENTIAL MODEL. Kaminskii, V. A.; Orlov, Yu. V. (Moscow State Univ.). Yadern. Fiz., 4: 728-36 (Oct. 1966). (In Russian).

The amplitude of the virtual process $A \rightarrow B + C$ is calculated by the spectral method as a function of the momentum transfer, on the basis of the potential model with the nuclear potential, V(r), analytical for Re $r > 0$ and giving a good approximation to the Woods-Saxon potential. The analytical properties of the amplitude are investigated. It is shown that the existence of a nuclear radius makes it necessary to take distant singularities of the vertex part with respect to the momentum transfer into account, corresponding to diagrams, containing a virtual scattering of the particles B and C. It is found that the nuclear radius is not connected with any specific singularities of the vertex part (like, e.g., an essential singularity at infinity), independent of the model. (auth)

**2794** DEUTERON STRIPPING REACTION AS A SPECIAL CASE OF THE THREE-BODY PROBLEM. Baz, A. I.; Demin, V. F.; Kuzmin, I. I. Yadern. Fiz., 4: 737-43(Oct. 1966). (In Russian).

The deuteron stripping reaction is considered as a special case of the three-body problem of an infinitely heavy nucleus and two nucleons. The interaction between the nucleons is described in the approximation of an infinitely short nuclear-force radius, and the interaction between the nucleons and the nucleus by an optical potential without the imaginary part. A method is developed by which the three-body problem can be solved exactly numerically. The essence of the method is the reduction of the equation for the inelastic scattering amplitude to a one-dimensional Fredholm-type integral equation for a function, in terms of which the partial amplitudes of all possible processes are expressed: the stripping, disintegration, and elastic scattering of the deuteron. (auth)

**2795** THE INFLUENCE OF CORIOLIS FORCES ON $\alpha$- AND $\gamma$-TRANSITION PROBABILITIES IN NUCLEI. Grin, Yu. T.; Kamenskii, V. G. Yadern. Fiz., 4: 744-53(Oct. 1966). (In Russian).

The influence of Coriolis forces on electromagnetic and $\alpha$ transitions in atomic nuclei is considered. The calculated quantities are corrections to magnetic transitions and influence of Coriolis forces on the forbidden $\alpha$ decay of $^{235}$U. The theory is compared with experiments. (auth)

**2796** NEW APPROACH TO STRIPPING CALCULATIONS. Pearson, C. A. (Australian Atomic Energy Commission, Lucas Heights. Niels Bohr Inst., Copenhagen); Coz, M. Yadern. Fiz., 4: 754-64(Oct. 1966). (In Russian).

A new method is proposed for stripping-reaction calculations to replace the conventional distorted-wave Born approximation (DWBA). When the stripped particle encounters the nuclear surface, it is supposed that the surviving particle is released from its partner nucleons and is scattered from the nucleus alone. From this description a calculable stripping amplitude is obtained. This amplitude is calculated for special cases and is compared with experiment. (auth)

**2797** ON THE EQUATION FOR THE EFFECTIVE FIELD OF A SPHERICAL SYSTEM. THE 1f 7/2 SHELL. Sapershtein, E. E.; Khodel, V. A. Yadern. Fiz., 4: 701-6(Oct. 1966). (In Russian).

The behavior of a spherical system with an open sub-shell in a static external field is considered. Many-particle excited states of quasiparticles on the last level play an important role in the problem. The wave functions of quasiparticles in an open shell are constructed using an effective interaction, taking the core polarization into account. The results of the considerations for an isolated j-level are applied to the calculation of magnetic momenta and $\beta$ transition probabilities in the $1\,f\,\frac{7}{2}$ shell. (auth)

**2798** ISOTOPIC SHIFT IN SPHERICAL NUCLEI. Bunatyan, G. G. (Moscow Inst. of Engineering Physics). Yadern. Fiz., 4: 707-11(Oct. 1966). (In Russian).

The isotopic shift in spherical nuclei is calculated on the basis

of the finite Fermi system. The dependence of the isotopic shift on the constants introduced in the theory is considered, as well as its dependence on the neutron and proton nuclear configurations. (auth)

**2799** MAGNETIC DIPOLE TRANSITION OPERATOR IN PHENOMENOLOGICAL MODELS OF COLLECTIVE QUADRUPOLE EXCITATIONS IN EVEN–EVEN NUCLEI. Grechukhin, D. P. Yadern. Fiz., 4: 691-700(Oct. 1966). (In Russian).

The structure of the angular momentum operator is analyzed on the basis of the postulates for the phenomenological models of collective quadrupole excitations (both vibrational and rotational). The magnetic moment operator is developed in terms of the powers of the nuclear deformation parameters. It follows from the analysis that the collective magnetic dipole transitions of even nuclei are, generally speaking, not strictly forbidden, since the magnetic moment and angular momentum operators differ. This result contradicts the conclusions of Lipas, obtained using the hydrodynamical model of collective motion. This discrepancy is due to the fact that Lipas did not consider the properties of the magnetic moment and angular momenta as quantum operators, operating on the collective variables, so that his results refer to the collective classical motion of an ideal liquid droplet. (auth)

**2800** POLARIZATION EFFECTS IN THE INELASTIC SCATTERING OF FAST ELECTRONS ON NUCLEI. Simenog, I. V. (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Yadern. Fiz., 4: 812-18(Oct. 1966). (In Russian).

Polarization effects in the inelastic scattering of fast electrons on nuclei are considered. General formulas are obtained for oriented nuclei and arbitrary polarizations of the incident electrons. The influence of the structure of nuclear matrix elements on the final-state electron polarization is elucidated for the example of the Fermi gas model for spinless particles. (auth)

**2801** ELASTIC AND INELASTIC MAGNETIC SCATTERING OF ELECTRONS ON LIGHT NUCLEI. Kabachnik, N. M.; Grishanova, S. I. (Moscow State Univ.). Yadern. Fiz., 4: 819-24(Oct. 1966). (In Russian).

The cross section is calculated for the elastic and inelastic magnetic scattering of high-energy electrons on 1p shell nuclei. The calculations were performed in the framework of the shell model with intermediary coupling. The dependence of the results obtained on the type of coupling and the model parameters is discussed. (auth)

**2802** THEORY OF MEAN PRIMARY CHARGE DISTRIBUTION IN LOW ENERGY FISSION OF EVEN-EVEN NUCLEI. Noerenberg, W. (Technische Hochschule, Munich). Z. Phys., 197: 246-61(1966).

A molecular model of fission is introduced in which the compound nucleus before scission is described. The ground state wave function is assumed to be a BCS wave function. The single-particle wave functions are expanded in terms of eigenfunctions of the unperturbed spherical fragments. The BCS wave function is determined from the minimum condition for the total energy. The fragment masses, the centers of mass, and the total proton and neutron numbers are kept constant. The resulting BCS and Hartree-Bogoliubov equations are solved approximately within the framework of an extended Nilsson model. The numerical results for the charge distribution in low-energy fission of $^{236}U$ are in agreement with experiments. The heavier (lighter) fragment has on the average 0.5 protons less (more) than expected on the basis of the so-called unchanged charge distribution (UCD). At magic configurations the charge distribution shows characteristic deviations from the average value due to the shell structure of the fragments. The charge distribution seems to result mainly from three competing effects: (a) from the level density of the unperturbed fragments in the vicinity of the Fermi energy, (b) from the Coulomb interaction between the fragments, and (c) from the asymmetry energy. (auth)

**2803** A POSSIBLE ORIGIN OF HARD CORE IN NUCLEAR FORCE. Kobayashi, Tsunehiro (Waseda Univ., Tokyo). Progr. Theoret. Phys. (Kyoto), 36: 412-13(Aug. 1966).

It was previously pointed out by Machida and Namiki that the hard core in nuclear force may originate from the many-fermion nonlocal structure of baryons and mesons. A possible origin of the hard core is discussed along this line of thought, under the assumption that the baryon is a nonrelativistic bound system of three fundamental fermions with wave function belonging to the 56-dimensional representation of the $SU_6$ symmetry. (L.B.S.)

**2804** SUM RULES FOR MAGNETIC MOMENTS OF SPIN 1 AND 3/2 NUCLEI. Hosoda, Masataka; Yamamoto, Kunio (Osaka Univ.). Progr. Theoret. Phys. (Kyoto), 36: 426-7(Aug. 1966).

An exact sum rule for the magnetic moments of a spin-$\frac{1}{2}$ particle is shown to hold also for spin 1 and $\frac{3}{2}$ nuclei. (L.B.S.)

**2805** CASCADE GAMMA QUANTUM EMISSION BY NUCLEI ORIENTED BY THE CAPTURE OF POLARIZED THERMAL NEUTRONS. Michalec, Rudolf (Inst. of Nuclear Research, Czechoslovak Academy of Science, Rez). Cesk. Cas. Fys., 16: 404-6(1966). (In Czech).

Tables of numerical values of the circular polarization, $P_c$, were calculated for the first, second, and third members of several most probable cascades. From the tables it is evident that the preceding transitions perceptibly change the degree of circular polarization of gamma quanta emitted from the following steps of the cascade. If semi-conductor gamma detectors are used, it will be possible to separate individual transitions and to measure their circular polarization. From experimental data it should be possible to determine the spin of individual levels of the emitting nuclei of the multipolar series of transitions and also the combined relation for the emission of gamma quanta. (TTT)

**2806** USE OF CONSERVED VECTOR CURRENT THEORY IN FIRST FORBIDDEN $\beta$-DECAY. Damgaard, J. (NORDITA, Copenhagen); Winther, A. Phys. Lett., 23: 345-6(Nov. 7, 1966).

It is shown that uncritical use of the formula connecting the first forbidden $\beta$-decay matrix elements $\langle\alpha\rangle$ and $\langle\mathbf{r}\rangle$ is unjustified. (auth)

**2807** ISOSPIN MIXING IN DEUTERON REACTIONS. Drachman, Richard J. (Goddard Space Flight Center, Greenbelt, Md.). Phys. Rev. Lett., 17: 1017-19(Nov. 7, 1966).

An adiabatic approximation was previously used to evaluate the polarization potential acting on a deuteron at any distance from a fixed point charge. It is shown that this previous work implies a value for the isospin impurity carried into the reaction by the distorted deuteron. Numerical results are presented for the reaction $^{12}C(d,\alpha)^{10}B$, which had been used to study the isospin impurity of $^{14}N$. (D.C.W.)

**2808** HIGH-ENERGY PROTON-NUCLEUS SCATTERING AT SMALL ANGLES. Benestad, Olav; Olsen, Haakon (Norges Laererhoegskole, Trondheim, Norway). Phys. Rev. Lett., 17: 1031-3(Nov. 7, 1966).

The scattering of high-energy protons by nuclei at small angles was analyzed neglecting Coulomb-scattering interference effects and assuming that spin effects are negligible at small angles. A simple extension of the proton-proton shadow scattering model to proton-nucleus scattering was made assuming a Gaussian overlap function for proton-nucleus scattering, which is also valid for proton-proton scattering. (D.C.W.)

**2809** NUCLEON-NUCLEON SOFT CORE CENTRAL POTENTIAL. Eikemeier, Horst; Hackenbroich, Hans H. (Univ., Tuebingen, Ger.). Z. Phys., 195: 412-18(1966).

A central nucleon-nucleon potential with a soft core for the singlet-even and the triplet-even states was calculated. The radial dependence of these potentials is given by a sum of one repulsive and two attractive Gaussians; therefore matrix elements with shell-model and cluster-model like functions may be calculated quite easily. The potentials are fitted to reproduce the phase shifts up to 300-MeV laboratory energy and the binding energy of the deuteron. (auth)

**2810** GENERAL ASYMMETRIC ROTOR LEVEL STRUCTURE OF SOME EVEN NUCLEI. Suarez, J. F.; de Aisenberg, E. Y. (Comision Nacional de Energia Atomica, Buenos Aires). Nucl. Phys., 6701A: 449-58(1967).

The quasi-adiabatic general asymmetric rotor model for nuclei was applied to the level structures of $^{56}Fe$, $^{96}Mo$, $^{106}Pd$, $^{110}Cd$, $^{132}Xe$, $^{148}Sm$, $^{152}Sm$, $^{154}Gd$, $^{156}Gd$, $^{182}W$, $^{186}Os$, $^{188}Os$, and $^{192}Pt$. The agreement of predicted levels with experimental data is satisfactory for nuclides at least 7% apart from magic numbers. The electric quadrupole transition probabilities are predicted within a factor 2(1.5) in 72% (53%) of the cases. (auth)

**2811** DEDUCTION OF NON-SINGULAR POTENTIALS FROM SCATTERING PHASE SHIFTS. II. CHARGED PARTICLES. Swan, Peter (Univ. Laval, Quebec). Nucl. Phys., 6701A: 436-48 (1967).

A practical method is given for charged-particle elastic scattering, enabling phase-equivalent, nonsingular potentials to be deduced from $\eta_l(k)$ curves. The method is an extension of earlier work on neutral-particle scattering, employing the distorted plane wave approximation. The approximate potential is obtained as a finite series of short-range functions, such as the exponential function, accurate to within several percent. An iterative method previously employed enables the error in the potential to be reduced successively by factors of 2 or more per cycle, where the data so justify it. (auth)

**2812** TRANSFORMATION SCHEME FOR HARMONIC-OSCILLATOR WAVE FUNCTIONS. Chasman, R. R.; Wahlborn, S. (Research Inst. for Physics, Stockholm. Royal Inst. of Tech., Stockholm). Nucl. Phys., 6701A: 401-6(1967).

Algebraic expressions are derived for the coefficients of transformations between various representations of harmonic-oscillator wave functions. The transformation scheme which is introduced can be used to evaluate Moshinsky coefficients, but its flexibility makes it useful in a wider range of contexts. (auth)

**2813** COMPARISONS OF NUCLEAR MOMENTS OF INERTIA WITH PARTICLE NUMBER CONSERVING STATES. Rich, M. (Los Alamos Scientific Lab., N. Mex.). Nucl. Phys., 6701A: 407-11(1967). (LA-DC-8028).

A comparison is made of moments of inertia for several rare-earth nuclei calculated with BCS states, projected BCS states, and projected states where minimization followed projection. (auth)

**2814** POWER SERIES IN ENERGY FOR COULOMB WAVE FUNCTIONS. Swan, P. (Univ. Laval, Quebec). Nucl. Phys., 6701A: 412-22(1967).

An expansion in powers of energy only is given for the regular Coulomb wave function $F_l(k,r)$. A corresponding expansion is derived for the irregular Coulomb wave function $G_l(k,r)$, convergent for $k^2 < \frac{1}{4}\beta^2$, $\beta = (2\mu/\hbar^2)\ ZZ'e^2$ and without the usual term logarithmic in energy. An alternative (convergent) expansion in powers of energy is found containing a ln k term inside an expression $h(\alpha)$. The latter reduces to a series in powers of energy for $k^2 < \frac{1}{4}\beta^2$ and to a series in inverse powers of energy plus the ln k term for $k^2 > \frac{1}{4}\beta^2$. The series is simpler in form that the earlier series in powers of r and are more convenient for analytical manipulation. (auth)

**2815** SHAPE-DEPENDENT PHASE-SHIFT EXPANSIONS FOR CHARGED-PARTICLE SCATTERING. Swan, P. (Univ. Laval, Quebec). Nucl. Phys., 6701A: 423-35(1967).

Neutral and charged-particle shape-dependent formulas for scattering phase shifts are compared, and their validity is discussed. The charged-particle formulas are derived for general l-values using the usual Coulomb wave function expansions and expansions in powers of energy only of the Coulomb wave functions with the irregular function $G_l(k,r)$ convergent only for $k^2 < \frac{1}{4}\beta^2$, $\beta = (2\mu/\hbar^2)\ ZZ'e^2$. The formulas derived via the second approach are very simple compared to the complicated expressions obtained elsewhere but have a useful shape-independent region for $l = 0$ (and even a region of validity) only for composite nuclei with multiple charges ($\beta$ not small). It is shown that the two sets of results are compatible. (auth)

**2816** DIFFRACTION MODEL TREATMENT OF POLARIZATION IN DIRECT NUCLEAR REACTIONS. Walls, D. F. (Univ. of Auckland, N. Zeal.). Nucl. Phys., 6701A: 353-60(1967).

A simple diffraction model describing the polarization of protons in a $(d,p)l_n = 0$ reaction, where spin-orbit distortion is present in the outgoing proton channel, is presented. The model is also used to describe the polarization in the inelastic scattering of spin-$\frac{1}{2}$ particles with zero orbital angular momentum transfer. (auth)

**2817** DEUTERON STRIPPING MECHANISM AT LOW ENERGIES. Goldfarb, L. J. B.; Wong, K. K. (The Univ., Manchester, Eng.). Nucl. Phys., 6701A: 361-78(1967).

Consideration is given to the validity of the saddle-point treatment as applied by Ter-Martirosyan to (d,p) stripping reactions in situations where the Coulomb field is predominant. The approximation is modified to allow for an assessment of the dependence of the angular distribution on the l-value of the transferred neutron. A consequence of this approximation is that the $(p,\gamma)$ angular correlation associated with the decay of the residual nucleus is symmetric with respect to a direction in the reaction plane supplementary to that of the nuclear recoil axis. Furthermore, it is found to depend on the j-value of the neutron but not on the l-value. A study of low-energy (d,n) reactions and (d,p) reactions with larger Q-values shows that the yields are much lower than those associated with (d,p) Coulomb stripping reactions and that there is a much greater dependence on conditions near or within the nuclear surface. (auth)

**2818** CALCULATION OF THE GROUND-STATE PROPERTIES OF NUCLEAR MATTER USING GREEN'S FUNCTIONS. Foster, Theodore Charles. Seattle, Univ. of Washington, 1965. 92p.

Thesis.

A calculation of the properties of a many-body system of infinite nuclear matter is considered. It is based on the Martin-Schwinger-Puff Green's Function formalism and it numerically investigates the important features of what is called the $\wedge^{10}$ approximation to the Green's Function equations. The central feature of this approximation is the fact that the energy denominator or the propagator in the T-matrix equation includes one "dressed" and one free particle, not two free particles as is the usual case. This approximation yields the BCS theory of superconductivity and contains more terms of the perturbation series expansion than does $\wedge^{00}$ and so $\wedge^{10}$ is considered a better approximation. The problem involves the solution of the integral T-matrix equation. This is accomplished using a separable, non-local two-nucleon interaction fit to several sets of scattering data. The work was done numerically on an electronic computer. The effects of the parts of the two-particle interaction omitted here are discussed, and it is shown that with the proper correction terms the results reported here are not inconsistent with experiment. (Dissertation Abstr.)

# REACTOR TECHNOLOGY

## Central Power Reactors

*Refer also to abstracts 1755, 1915, 1918, 1955, 1957, 1958, 1960, 1961, and 2864.*

**2819** (ANL-7194) GENERAL INPUT SPECIFICATIONS FOR ANL REACTOR PROGRAMS. Butler, M.; Greenspan, H. (Argonne National Lab., Ill.). Apr. 1966. Contract W-31-109-eng-38. 38p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Standard-problem specifications are presented for the programming of multigroup diffusion and transport programs for the CDC-3600. Seven categories for input specifications are discussed: identification and program-dependent input data, geometry, boundary and interface conditions, material assignment, type designation, initial source/flux values, and cross-section modification. (D.L.C.)

**2820** (CEND-541) FEASIBILITY OF DEVELOPING SIMPLE CALCULATIONAL PROCEDURES FOR CHECKING HEAVY-ISOTOPE CONTENT IN OPERATING FUEL ELEMENTS. Valerino, Michael F.; Roszto czy, Zoltan R. (Combustion Engineering, Inc., Windsor, Conn. Nuclear Div.). Oct. 31, 1965. Contract AT(38-1)-207. 35p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Steps involved in the use of the ISOCHECK calculational approach for independent verification of nuclear loss and production in commercial power reactors are described. A survey of the commercial power reactors was made to determine whether problems related to core geometrical layout and fuel, shim, and control-element management introduce difficulties which prevent essentially straightforward application of the ISOCHECK method: it is concluded that the basic ingredients of the method can be preserved in its application to the specific reactors. It is also concluded that it is technically feasible to develop a practical method for checking isotope content in reactors having thermal or near-thermal neutron spectra. The method is sufficiently general so that it may also apply to other types of reactors, e.g., the highly epithermal and fast-spectrum reactors. It is not now possible to draw definitive conclusions as to applicability to the nonthermal reactor types due to lack of pertinent experimental information. (J.R.D.)

**2821** (CONF-661003-10) FUELED-GRAPHITE ELEMENTS FOR THE GERMAN PEBBLE-BED REACTOR (AVR). Burkett, M. N.; Eatherly, W. P. (Union Carbide Corp., Lawrenceburg, Tenn. Carbon Products Div.); Harms, W. O. (Oak Ridge National Lab., Tenn.). [1966]. Contract W-7405-eng-26. 31p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From AIME Nuclear Metallurgy Symposium on High Temperature Nuclear Fuels, Delevan, Wis.

The development, fabrication, testing, and evaluation of spherical graphite fuel elements for the first core loading of the German Pebble-Bed Reactor (AVR) are described. The initial core loading contains 30,000 6-cm-diameter graphite spheres, each with 6 grams of heavy metal as duplex, pyrolytic-carbon-coated $(Th,U)C_2$ particles. The spherical particles were prepared by a plasma melting technique and were coated with two structurally different layers of pyrolytic carbon in fluidized bed coaters. The fuel element was fabricated by injection molding a graphite matrix containing the coated particles into a 1-cm-thick machined ATJ graphite shell. The major requirements for these elements include fission-product retention, dimensional stability, and resistance to impact, abrasion, and oxidation. A description is given of the development of test criteria and the production quality assurance procedures used in meeting these requirements. Almost one-half the cost of the fuel elements was due to the quality assurance requirements which were understandably very stringent for this initial loading. Considerations for reducing costs of elements for future loadings are discussed. Details are presented regarding the irradiation proof tests and the fission-product-release guarantees for both loose coated particles and fuel elements. (D.L.C.)

**2822** (EUR-2966.f) LES REACTEURS A EAU LOURDE: BILAN ET PERSPECTIVES. (The Heavy Water Reactors: Present Status and Prospects). Bahbout, A.; Leny, J. C. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 42p. (CONF-660552-1). Dep. mn.

From International Study Days on Modern Electrical Power Stations, Liege, Belgium.

The advantages of this family of reactors, from the economic, political, and long-term nuclear planning points of view are recalled. A brief description is given of the main version developed in Europe, of the pressure-vessel type (MZFR, MARVIKEN) as well as of the pressure-tube type (EL-4, SGWR, ORGEL, etc. . .). The performance of these reactor types, in terms of fuel burnup, specific heavy water investment, and steam conditions at the inlet to the turbine, are discussed. The main problems relative to each of these reactor types are pointed out as well, with the solutions proposed by their promoters. As to the prospects of future development, first those common to this entire family of reactors are presented, such as increase of the installed power of the plant, reduction of the production cost of heavy water and of the indirect charges, enrichment, etc. The development lines specific to each group of reactor types are thereafter commented; the groups are classified according to the nature of the coolant. (auth)

**2823** (EURAEC-1713) SAXTON PLUTONIUM PROJECT. Quarterly Progress Letter for the Period Ending September 30, 1966. Nelson, N. R. (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). Oct. 1966. Contract AT(30-1)-3385. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

A program is being conducted to operate the Pu fuel for at least one equivalent full power year in the Saxton reactor, to analyze the performance of the Pu portion of Core II, and to examine irradiated fuel samples. Measurements made during the nuclear analysis of operating performance are reported. (D.L.C.)

**2824** (GA-6949) THE USE OF MODELS IN PCRV DESIGN. Marsh, R. O.; Rockenhauser, W. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Mar. 11, 1966. Contract AT(04-3)-167. 32p. (CONF-660112-2). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From American Society of Civil Engineers, Structural Engineering Conference, Miami Beach, Fla.

The development of prestressed concrete reactor vessels (PCRV) in the U.S. and Europe is reviewed. It is noted that the PCRV is a structure that replaces primary pressure vessels of conventional nuclear plants and is subjected to full primary system pressure. The advantages associated with the PCRV are categorized as economic and safety. Design of an instrumented model of a PCRV is described and use of information gained from the model is discussed. (J.R.D.)

**2825** (GA-7183) ADVANCES IN FUEL ELEMENT DESIGN AND MATERIALS. Turner, R. F.; Goeddel, W. V. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). June 17, 1966. Contract AT(04-3)-633. 20p. (CONF-660606-54). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Nuclear Society Meeting, Denver.

Development of an improved HTGR fuel element of simplified construction which appears capable of high performance at high burnups for long periods of time is discussed. The element utilizes beds of coated fuel particles packed in holes drilled in a hexagonal shaped graphite block. The development of this element was made possible to a large extent by significant advances in coated particle technology. BISO-type coated particles were irradiated to approximately end-of-life burnups in instrumented capsules showing excellent integrity and a high retentivity of fission products. These advances offer possibilities of low fuel costs which result in low total power costs in a system having high thermal efficiency. (auth)

**2826** (NP-16347) REPORT AND ACCOUNTS OF THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY FOR THE YEAR ENDED 31ST MARCH, 1966 TOGETHER WITH THE COMPTROLLER AND AUDITOR GENERAL'S REPORT ON THE ACCOUNTS. (United Kingdom Atomic Energy Authority, London (England)). Aug. 8, 1966. 120p. Dep. mn. BIS $2.10; HMSO 10s. 6d.

The following general areas of research during this period are outlined as follows; (1) finance, accounts, and contracts, (2) trading report, (3) production factories, (4) reactor development program, (5) general research and development, (6) nuclear fusion and plasma physics research, (7) detection of nuclear explosions, (8) radioisotopes, (9) diversification and exploitation, (10) health and safety, and (11) international relations. (M.O.W.)

**2827** (NP-16359) FOURTEENTH ANNUAL REPORT FOR THE YEAR ENDED 30TH JUNE, 1966. (Australian Atomic Energy Commission). 104p. Dep. mn.

Developments in research carried out by the AAEC on nuclear power, peaceful uses of nuclear explosives, nuclear desalination, raw materials, and radioisotopes are reported. (P.C.H.)

**2828** (ORNL-4016) THE MODIFIED U-3 CODE: A THERMAL-HYDRAULIC CODE FOR AXIAL FLOW WITH MIXING IN FUEL BUNDLES. Sanders, J. P. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 51p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

This code was originally written at Chalk River for the thermal-hydraulic analysis of axial flow with intersubchannel mixing in multirod bundles. The code was modified by Combustion Engineering, Inc., for the HWOCR study and subsequently converted at ORNL to FORTRAN II for use with the IBM 7090. Hydraulic calculations are made with average property values and equivalent hydraulic characteristics for the subchannels. Thermal calculations are made by applying energy balances to successive axial increments. Mixing is represented by assuming that intersubchannel flow is proportional to the average linear velocity of the coolant, and the effect of this intersubchannel flow is included in the energy balances. Heat transfer coefficients and surface (cladding) temperatures are calculated at designated intervals. (auth)

**2829** (ORNL-TM-1623) TESTS OF VARIOUS PARTICLE FILTERS FOR REMOVAL OF OIL MISTS AND HYDROCARBON VAPOR. Hitch, B. F.; Ross, R. G.; McDuffie, H. F. (Oak Ridge National Lab., Tenn.). Sept. 7, 1966. Contract W-7405-eng-26. 26p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Various filter and adsorbent materials were examined for possible use in the removal of oil mists and hydrocarbon vapors. A controlled flow of oil was injected into a heated nickel reaction vessel to cause vaporization and some cracking of the oil. Helium flowing through the reaction vessel carried the oil mist and hydrocarbon vapor through a filter system. Filter effectiveness was determined by the use of a Perkin-Elmer Hydrocarbon Detector, gravimetric analysis, and gas chromatographic analysis. Good removal of mists was achieved by the use of a combination of felted metal fibers and ceramic fibers in a configuration proposed for use in the MSRE. Granulated charcoal removed hydrocarbon vapors ($C_6$ and above) in a manner consistent with the established adsorption isotherms for this material. (auth)

**2830** (UNC-5162) PERFORMANCE EVALUATION OF HEAT EXCHANGERS FOR SODIUM-COOLED REACTORS. Quarterly Technical Progress Report, July 1, 1966-September 30, 1966. Dischinger, R. H. (United Nuclear Corp., Elmsford, N. Y.). Oct. 20, 1966. Contract AT(11-1)-1452. 26p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The evaluation of the thermal-hydraulic and structural performance of heat exchangers for Na-cooled reactor plants was continued. The evaluation will be based on the results of tests of model heat exchangers [approximately 30 MW(t)] in the Sodium Components Test Installation (SCTI). An intermediate heat exchanger design and manufactured by ALCO Products, Inc., and a steam generator designed by ALCO Products, Inc. and manufactured by Baldwin-Lima-Hamilton Corporation are the first units to be tested. The Babcock and Wilcox (B and W) steam generator is to be tested next. Operation of the computer program for the ALCO heat exchangers, using plant shakedown data, was found satisfactory. Minor modifications are being made to the computer output format to assist evaluation. Recommendations were made regarding further steps to be taken to ascertain the severity of tube vibrations in the ALCO units. Review of heat exchanger test specifications were completed and most of the comments were resolved with the test operator. Familiarization with the B and W steam generator continued. Installation of thermocouples in the superheater bundle was witnessed. Areas for which structural evaluation procedures will be prepared have been established. (auth)

**2831** NOISE ANALYSIS OF PERIODICALLY PULSED REACTORS. Matthes, W. (EURATOM-CCR, Ispra, Italy). Nukleonik, 8: 329-33(Aug. 1966).

Within a simplified model for a periodically pulsed reactor it is shown, that a measurement of the cross-correlation between input and output and the autocorrelation of the output may be used for the determination of reactor parameters. The correlation between discrete stationary time-series obtained are performed by considering only quantities averaged over one period and available for manipulation at the end of each period. The quantities chosen are for the input the random integer number $\mathfrak{S}$ of source-events during one period and for the output the random integer number $\mathfrak{N}$ of counts per period. (auth)

**2832** GROWTH LAWS FOR BREEDER REACTOR SYSTEMS. Gruemm, H. (NUKEM, GmbH, Wolfgang, Ger.). Nukleonik, 8: 334-41(Aug. 1966). (In German).

Plutonium from a breeder reactor cannot be continuously inserted to form a new breeder, but must be accumulated up to at least a core charge. Consideration of this effect leads to a strongly delayed growth of breeder population contrary to the customary exponential formula. The improved formula could be applied to the two-cycle operation i.e., to the growth law of a system consisting of a breeder and a converter with a common plutonium economy. (tr-auth)

**2833** CONSTRUCTION OF THE LINGEN NUCLEAR POWER PLANT. Schmoczer, Ruediger (Allgemeine Elektrizitaetsgesellschaft, Frankfurt am Main). At. Strom., 12: 86-94(July-Aug. 1966). (In German).

The history and design of the Lingen nuclear power plant are described. The basic circuit forms and the most important flow schemes are treated and the expected operational characteristics are summarized. A review of the construction history to October 1966 is presented. (tr-auth)

**2834** CORROSION PROBLEMS IN NUCLEAR POWER STATIONS: AN INTRODUCTORY REVIEW. Le Surf, J. E. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. Nucl. Technol., 5: 35-6(July-Aug. 1966).

Corrosion problems of nuclear power reactors cooled by gas, water, organic and liquid metals are discussed with the methods used to overcome them. Consideration of the reactor core includes sheathing/coolant combinations and core containment by pressure vessels and pressure tubes. The out-reactor primary circuit may be either indirect cycle or direct cycle. Problems in the turbine/feedtrain system are only considered for the direct cycle concept. Evolution of each reactor concept leads to new materials problems so that research and development are continually required. (auth)

**2835** THERMAL BREEDING WITH THE THORIUM–URANIUM CYCLE WITH SPECIAL RESPECT TO $H_2O$ MODERATED NUCLEAR REACTORS. Wenzel, P. (VEB Atomkraftwerk, Berlin). Kernenergie, 9: 249-56(Aug. 1966). (In German).

Stationary regimes of operation of a thermal reactor utilizing the Th–U fuel cycle are studied, based on simple models of the multiplication cycle and fuel regime which enable to evaluate the most important cases occurring in practice by means of comparatively simple methods of calculation. The studies are made especially for the case of $H_2O$ moderated and cooled pressurized or boiling water reactors working with $ThO_2$–$UO_2$ fuel and Zr structural and canning material. It is stated that thermal breeding in the Th–U cycle principally is possible in those reactors, but the fuel doubling times prove to be in most cases in the range above 25 years and a breeding gain practically cannot be obtained. $H_2O$ moderated pressurized or boiling water reactors using the Th–U fuel cycle may be enabled to reproduce their fuel inventory and only for the first charge of the core a unique investment of fuel material is necessary. The total utilization of Th in such reactors has theoretically proved to be possible, but in practice it is limited by the high-level radioactive impurities being present in the fuel after long-term operation. (auth)

**2836** REACTOR OF THE LINGEN NUCLEAR POWER PLANT. Traube, Klaus (Allgemeine Elektrizitaetsgellschaft, Frankfurt am Main). At. Strom., 12: 80-5(July-Aug. 1966). (In German).

A general description and essential data for the reactor are presented. The reactor core, the pressure vessel, the safety containment, the control rod drive, the steam cut off, and the reactor control are described. (tr-auth)

**2837** NUCLEAR SAFETY. Volume 7, Number 3. Cottrell, Wm. B.; Jordan, W. H. (eds.). Contract W-7405-eng-26. One of the five Quarterly Technical Progress Reviews published for the Division of Technical Information, USAEC. Oak Ridge National Lab., Tenn., Spring 1966. 137p. GPO $1.00 Domestic, $1.20 Foreign.

Developments relevant to the analysis and control of hazards associated with nuclear reactors, operations involving fissionable materials, and the products of nuclear fission are reviewed. Primary emphasis is on safety in reactor design, construction, and operation. Safety considerations in fuel fabrication, spent-fuel processing, waste disposal, radioisotope handling, and related operations are also treated. Separate abstracts were prepared for 18 individual articles. (H.D.R.)

*For abstracts of individual papers see: 1463, 1754–1756, 1967, 2838–2844, 2877, 2878, 2899, 2900, 2927, and 2928.*

**2838** NOISE ANALYSIS IN REACTOR SAFETY. Thie, J. A. Nucl. Safety, 7: 271-8(Spring 1966).

The applications of techniques in the field of reactor noise (or random power fluctuations) to reactor safety are reviewed. Tabulations are given of essentially all the applications to date, both in zero-power reactors and in power reactors. These contribute to safety by determining the reactivity shutdown margin, monitoring for possible instabilities, and assisting in understanding the dynamic processes in the reactor. Examples of recent work are given along with an extensive bibliography. The significance of various experimental applications is pointed out, with comments regarding their future promise. (auth)

**2839** CONTRIBUTION OF SYSTEMATIC INCIDENT EVALUATION TO THE ACHIEVEMENT OF REACTOR SAFETY. Ablitt,

J. F. (United Kingdom Atomic Energy Authority, Harwell, Eng.). Nucl. Safety, 7: 279-92(Spring 1966).

The UKAEA procedure for collecting fault data from operating sites and then recording, analyzing, and disseminating the data is described. This procedure is a means for extracting the maximum practical value from the safety aspects of experience in reactor design and operation. Faults are classified into four categories: plant type, component type, fault importance, and fault type. These categories and the degree of detail involved in each are illustrated by extracts from the UKAEA Fault Code. Thus far, some 600 data items have been collected from 25 reactors in a six-month period. Six percent of events reported adversely affected the safety status of a reactor. The fault data are applied to a numerical evaluation of reliability. (auth)

**2840** SEVENTH TRIPARTITE INSTRUMENTATION CONFERENCE. Oakes, L. C. Nucl. Safety, 7: 328-33(Spring 1966).

The Tripartite series of conferences provide exchanges of information between personnel of Canada, the United Kingdom, and the United States. The seventh meeting emphasized instrumentation and control systems for the safety and control of nuclear reactors. Approximately 50 technical papers were presented in general categories, and 27 of these papers are reviewed. (auth)

**2841** EXPERIMENTAL INVESTIGATION OF CORE SPRAY. Uchida, Hideo (Tokyo Univ.). Nucl. Safety, 7: 338-42(Spring 1966).

Experimental investigations of core spray cooling for electrically heated simulated fuel-element assemblies are discussed. The purpose of a core spray is to prevent a sudden temperature rise of the fuel elements in a light-water-moderated reactor following a loss-of-coolant accident. (auth)

**2842** EFFECT OF ENGINEERED SAFEGUARDS ON REACTOR SITING. Culver, H. N. Nucl. Safety, 7: 342-6(Spring 1966).

Recent licensing trends are analyzed to provide some insight as to the acceptability and effectiveness of several engineered safeguards to reduce reactor siting distances. Engineered safeguards provided for U. S. water reactors are presented and an apparent engineered-safeguards factor is associated with each reactor. (H.D.R.)

**2843** STRENGTH OF STEEL CONTAINMENT SHELLS. Merkle, J. G. Nucl. Safety, 7: 346-53(Spring 1966).

Experimental and analytical research on the bursting strength of thin-walled cylinders with rigid ends is summarized. Definitions of failure and strength are presented, and the basic equations of plasticity are derived. A comparison is made between the strength predictions of plastic theory and the present ASME Code for both spherical and cylindrical containment shells. Also included are a tabulated summary of analytical solutions for thin-walled cylinders with rigid ends and an extensive bibliography. (auth)

**2844** CVTR OPERATING EXPERIENCE. Wagoner, C. C.; Nabow, S. E. Nucl. Safety, 7: 375-84(Spring 1966).

The operating experience of the Carolinas-Virginia Tube Reactor, including pertinent background information and related problems encountered in the checkout and operation of the plant, is described. (auth)

**2845** THE LATEST DEVELOPMENT STATE OF NUCLEAR POWER PLANTS. RESULTS OF THE THIRD GENEVA CONFERENCE AND OF THE PARTIAL SESSION OF THE WORLD POWER CONFERENCE IN LAUSANNE. Gilli, P. V. Elektrotech. Maschinenbau, 81: 619-49(1964). (In German).

A review is given of the technical state of development of various reactor systems, the methods for direct energy production, and the state of construction of nuclear power plants. Installation, construction, and heat engineering viewpoints are given special consideration. (J.S.R.)

**2846** ECONOMICS OF PLUTONIUM UTILIZATION IN PROGRAM OF NUCLEAR POWER. Iliffe, C. E. (United Kingdom Atomic Energy Authority, Risley, Eng.). 21p. (CONF-178-9). ORAU.

From European Atomic Energy Society's Symposium on Fuel Cycles for Power Reactors, Baden-Baden, Ger., Sept. 1963.

A detailed discussion of the economics of Pu-fueled fast power reactors is presented. (J.M.J)

**2847** SOME CONSIDERATIONS ON THE ROLE OF ADVANCED CONVERTER REACTORS. Stoller, Sidney M. (S. M. Stoller Associates, New York). 4p. (CONF-660606-33). ORAU. Gmelin, AED-CONF-66-203-60.

From American Nuclear Society Meeting, Denver, Colo.

A review was made of the progress of the advanced converter reactors. The probability of converter reactors becoming economically feasible is minimal. The HTGR is a demonstration project in progress which may be successful. (J.C.W.)

**2848** REACTOR LICENSING IN CANADA. Boyd, F. C. (Atomic Energy Control Board, Ottawa). 12p. (CONF-660516-3). ORAU. Gmelin, AED-CONF-66-138-1.

From Annual Conference on Organic and Heavy Water Reactors, Winnipeg, Can.

An order of the Atomic Energy Control Board is required for any nuclear reactor in Canada except those wholly owned and operated by the Federal Government. The prerequisites for the three stages of approval involved; site approval, construction permit, operating licence, and the criteria for approval are outlined. (auth)

**2849** INITIAL OPERATION OF THE DRAGON REACTOR EXPERIMENT. Shepherd, L. R. (OECD High Temperature Reactor Project, Winfrith, England). 12p. (CONF-660524-13). ORAU. Gmelin, AED-CONF-66-104-13.

From 2nd International Thorium Fuel Cycle Symposium, Gatlinburg, Tenn.

In the course of initial operating experience with the DRAGON reactor experiment, during which the reactor has been brought up to the specified power and coolant temperature levels, no fundamental problems have been encountered. All novel items such as the gas bearing circulators and the enclosed remotely operated charge machine have functioned correctly, and remarkable standards of leaktightness have been achieved. It will require two or three years of irradiation experience to establish confidence in any particular type of fuel or any variety of graphite used in the core. The future operation of the DRAGON reactor experiment is directed, to a large extent, towards the objective of developing this confidence in high temperature reactor fuel and core materials and to achieving progressive improvements in their behavior. (auth)

**2850** ACCUMULATED EXPERIENCE WITH NUCLEAR POWER PLANTS. Beatty, D. C.; Farbman, G. H. (Westinghouse Electric Corp., Pittsburgh). 24p. (CONF-660429-6). ORAU. Gmelin, AED-CONF-66-098-14.

From American Power Conference, 28th Annual Meeting, Chicago.

Information is presented on nuclear plant reliability and operating performance in such a manner that utility engineers can better evaluate the usefulness of a nuclear plant to their system. Operating records of an old nuclear plant, an experimental nuclear plant, and a new nuclear plant are given. The operational factors achieved by Yankee, BR-3, and Selni are not the ultimate goal to be achieved. These are factual numbers from operating reports of first and second generation nuclear power plants. Designers strive to advance the state of the art and improve reliability with each new nuclear plant. Nuclear power plants are becoming more competitive and are establishing themselves as a preferenced power source for utility systems. (auth)

**2851** APPLICATION OF ADVANCED NUCLEAR REACTORS TO UTILITY SYSTEMS. Nordman, D. A.; Smith, E. E.; Wright, J. H. 28p. (CONF-660606-30). ORAU. Gmelin, AED-CONF-66-203-52.

From American Nuclear Society Meeting, Denver, Colo.

A study is made of the economic impact of the breeder reactor on the electrical industry. The high gain breeder will be a valuable addition to future utility expansion patterns as an economic unit for base load application and to reduce fuel costs for water reactors by reducing the amount and price of U and provide a market for the water reactor Pu. (J.C.W.)

**2852** ECONOMIC POTENTIAL OF VARIABLE ENRICHMENT FUEL ELEMENTS FOR POWER REACTORS. Greenspan, Ehud; Cady, K. B.; Howe, J. P. (Cornell Univ., Ithaca, N. Y.). 34p. (CONF-660606-26). ORAU. Gmelin, AED-CONF-66-203-37.

From American Nuclear Society Meeting, Denver, Colo.

Improvements in the thermal and neutronic performance of fuel elements for power reactors are possible by varying the enrichment across the elements. Shifting the concentration of the fissile nuclides from the center of the fuel element towards its periphery will result in a flatter temperature profile with the consequence of much higher possible power per unit fuel element length. Optimized power plants with the proposed fuel elements are expected to have thicker fuel elements with smaller overall fuel length for a given plant power output. Larger moderator to fuel ratio to take care of the increased heat rating may improve the neutron economy in the lattice. The analysis done in this work for water cooled, $UO_2$ fueled reactors, indicates that a saving of 6% in the fuel cycle cost is a very conservative estimate of the economic potential of the proposed elements. (J.C.W.)

**2853** DEVICE FOR REGULATING A NUCLEAR REACTOR, COMPRISING CONTROL ELEMENTS SPLIT INTO TWO HALVES. Wendler, Gerhard (to Brown, Boveri/Krupp Reaktorbau GmbH). German Patent 1,225,316. Sept. 22, 1966. Filed Apr. 30, 1964.

The device comprises tubular control elements split at the cen-

ter into two halves which are arranged on opposite sides in parallel channels of the reactor core. They are so coupled together by a cable that on operation of the device the halves on opposite sides in neighboring channels move simultaneously by the same distance in opposite directions to each other. (Gmelin Inst.)

**2854** NUCLEAR REACTOR WITH FUEL OR BREEDER ELEMENT UNITS OF CYLINDRICAL SHAPE. Ott, Karl (to Gesellschaft fuer Kernforschung mbH). German Patent 1,225,779. Sept. 29, 1966. Filed Nov. 29, 1960.

A nuclear core comprises rotary fuel or breeder units in the form of cylindrical drums, each of which is mounted for rotation about their lengthwise axis and has an eccentric fuel or breeder region with respect to its axis of rotation. (Gmelin Inst.)

**2855** NUCLEAR REACTOR PLANT. Villadsen, Peter Mogens (to Aktieselskabet Burmeister and Wains Maskin OG Skibsbyggeri). German Patent 1,226,223. Oct. 6, 1966. Priority date Sept. 20, 1962, Denmark.

For the reduction of the sudden pressure rise caused by water vapor flowing into the safety building from pressurized cooling water of the reactor, liquid filled surface condenser elements are located near the nuclear reactor within the building in such a way that the escaping vapor is forced to pass over these elements. (Gmelin Inst.)

**2856** PEBBLE BED REACTOR CORE. Gruemm, Hans; Jauk, Hermann; Schwarz, Norbert (to Oesterreichische Studiengesellschaft fuer Atomenergie GmbH). German Patent 1,223,465. Aug. 25, 1966. Priority date Aug. 4, 1962, Austria.

A pebble bed reactor core through which the gaseous coolant is circulated upwardly is provided with means which prevent the levitation of fuel by forcing the entire filling of the core region with pebbles independent of the filling height. This can be achieved by the insertion of a displacing body into the core or by moving the walls of the core relative to each other. (tr-auth)

**2857** BOILING REACTOR. Friedl, Johann. German Patent 1,226,220. Oct. 6, 1966. Filed May 5, 1959.

A heterogeneous or homogeneous nuclear boiling water reactor with a liquid moderator consists of an outer pressure vessel with a dome in the lower portion of the outer pressure vessel to form an inner pressure vessel in which the nuclear reaction takes place. An annular space between the outer pressure vessel and the dome is connected with the space above the dome. A device maintains a water level in the outer pressure vessel above the dome below the top of the outer pressure vessel and heat-exchanger tubes are situated in the upper portion of the outer pressure vessel above the water level for extracting heat from the steam generated. (tr-auth)

**2858** NUCLEAR REACTOR OPERATED WITH THICKENED FUEL SLURRIES. Helmis, Guenther; Schimmel, Wolfgang; Meyer, Klaus (to VEB Atomkraftwerk Rheinsberg mit Betriebsteil Berlin). German Patent 1,223,964. Sept. 1, 1966. Filed July 15, 1959.

To prevent sedimentation, the slurries are circulated through tubes of varying cross sections, the inner surfaces of which are provided with slide faces. The slide faces are obtained by coating the inner surface of the tubes with a polymerizable or polymerized siliceous material. (tr-auth)

**2859** METHOD OF CONTROLLING A NUCLEAR REACTOR PLANT. Kaegi, Jakob (to Gebrueder Sulzer AG). German Patent 1,223,071. Aug. 18, 1966. Priority date Sept. 13, 1963, Switzerland.

A method is given of controlling a nuclear reactor plant having flow through it a coolant which receives heat as it flows and then gives up the heat received to two separate evaporable load medium circuits. Firstly, control the total rate of feed of load medium to the two load medium circuits dependent on the temperature of the coolant entering the reactor and secondly, adjust the individual rates of feed of load medium to the two circuits simultaneously in dependence upon a comparison of the live vapor pressures in the two circuits to tend to equalize the two live vapor pressures. (tr-auth)

**2860** NUCLEAR REACTOR PLANT. Kaegi, Jacob (to Gebrueder Sulzer AG). German Patent 1,221,372. July 21, 1966. Priority date Mar. 20, 1963, Switzerland.

A nuclear reactor plant in which heat from the reactor is transferred to a working medium by heat exchange from a gaseous carrier which cools the reactor, the pressure of the heat carrier in the heat exchange being higher than that of the working medium, and has a number of parallel-connected heat exchangers which can be individually isolated from the heat carrier circuit, is provided with devices for the detection of the presence of heat carrier in the working medium in each heat exchanger. (tr-auth)

**2861** PRESSURE VESSEL FOR A NUCLEAR REACTOR. Beliaev, Karl Ivan Gunnar (to Aktiebolaget Atomenergie). German Patent 1,221,370. July 21, 1966. Priority date Aug. 22, 1963, Sweden.

A double-walled pressure vessel is so designed that the pressure forces the elastically deformable inner wall outward which is made of steel until it lies on the inside of the outer wall which is made of concrete and absorbs further pressure rises. (tr-auth)

**2862** BOILING NUCLEAR REACTOR. Friedl, Johann. German Patent 1,225,777. Sept. 29, 1966. Filed May 5, 1959.

A heterogeneous or homogeneous boiling nuclear reactor with a liquid moderator consists of a reactor vessel containing the boiling liquid. A separate heat exchanger vessel is situated outside and above the reactor vessel which is connected to the reactor vessel by means of an open vertical tube (riser), the lower end of which is immersed into the boiling liquid of the reactor vessel and the upper end of which passes through the bottom of the heat exchanger vessel. A pipe is provided with a valve and connects the upper portion of the heat exchanger vessel with the upper portion of the reactor vessel which encloses the space above the level of the boiling liquid. (tr-auth)

**2863** NUCLEAR REACTOR PLANT WITH HEAT EXCHANGERS WITHIN THE PRESSURE VESSEL. Stuermer, Walter (to Brown Boveri/Krupp Reaktorbau GmbH). German Patent 1,223,462. Aug. 25, 1966. Filed Feb. 16, 1963.

The inlet and outlet chambers of the heat exchangers as well as the coolers are located in the upper portion of the pressure vessel which is separated from the lower portion containing the gas-cooled core and the heat exchangers by means of a partition resting on supporting surfaces attached to the wall of the pressure vessel. (tr-auth)

## Marine and Portable Power Reactors

**2864** (KR-109) SURVEY OF ACTIVITIES, 1965. Aabakken, Bjarne (ed.) (Institutt for Atomenergi, Kjeller (Norway)). Feb. 1966. 112p. Dep. mn.

A survey is presented of the 1965 activities of the Kjeller Research Establishment. The fields covered in this survey includes reactor development, neutron physics, chemistry, metallurgy, isotopes, safety, and health physics. (D.L.C.)

## Rocket and Space Reactors

*Refer also to abstract 1529.*

**2865** (AD-635232) SN TRANSPORT CALCULATIONS FOR A GASEOUS CORE REACTOR. Bloemker, Carl F. (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering). Mar. 1966. 104p. (GSP/PH-66-1). CFSTI $6.00 cy, $0.75 mn.

Thesis.

A nuclear analysis was performed on a gaseous core cavity reactor suitable for space propulsion. The system consisted of a spherical gaseous core reactor surrounded by a C–Be reflector. To carry out this analysis, the angular segmentation (Sn) method was applied to the conservative form of the Boltzmann Equation to obtain a set of finite difference equations. The finite difference equations were then incorporated into a computer code. The computer code was programed for the IBM 7094 coupled system using Fortran IV. The code was first applied to an idealized gas core reactor. The difference in critical mass from a previous calculation was 8%. After this check on the reliability of the code, a parametric study on the gaseous core reactor was performed. The results of this study, which determined the critical mass as a function of core radii and design thrust, are presented. (auth)

**2866** (GA-7190) TUNGSTEN NUCLEAR ROCKET. PHASE II, FINAL REPORT. PART I. Bardes, R. G.; Bohren, C. F.; Cohen, S. C.; Peak, J. C. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). June 15, 1966. Contract SNPC-27. 93p. (NASA-CR-54986).

Further critical experiments and nuclear analyses which were performed as part of a feasibility study of the Tungsten Water-Moderated Nuclear Rocket Reactor are described. A description of the critical facility and the critical assemblies is given. Two different core configurations were assembled; each core contained 121 fuel elements on a 3.0-in. pitch. The cores were water-moderated and surrounded by a beryllium reflector. Excess reactivity was held down by a $Cd(NO_3)_2$ solution contained in 204 poison tubes throughout the core. The fuel element consisted of an assembly of enriched U–Al alloy, depleted U, W foil, and structural Al. Additional W was added to each of the two cores for power zoning. The purpose of the zoning was to flatten the radial power and tailor the axial power profile. A radially zoned core was first constructed by the addition of W foils to fuel ele-

ments in a central core region; a fully zoned core was then constructed by adding W to an axial region of each fuel element of the radially zoned core. Experimental results include the excess reactivity available in the cores, the worth of poison tubes of different Cd concentration at various radial locations, the isothermal temperature coefficient of the assemblies, power distributions throughout the cores, and pulsed neutron measurements. The experimental results are compared with analysis. Nuclear analysis of the assemblies required careful treatment of the heterogeneous nature of the core. Detailed analyses which accounted for the two-dimensional cell structure, resonance overlap, and two-region resonance effects were compared with experimental results; good agreement was found for both water- and Be-reflected assemblies, zoned and unzoned assemblies, and assemblies with and without Cd poison. (auth)

**2867** (NAA-SR-11935) SNAP 10A SYSTEM OPTIMIZATION. Soske, P. L. (ed.) (Atomics International, Canoga Park, Calif.). Aug. 1, 1966. Contract AT(11-1)-Gen-8. 247p. Dep. mn. CFSTI $6.00 cy, $1.25 mn.

Since the configuration of the SNAPSHOT-1 system was established, many technological advances have been made in related programs. These programs include the SNAP 2 and SNAP 8 Reactor Development Programs, the SNAP Reactor Improvement Program, and the Advanced Thermoelectric Development Program. These advances in the technology and the results of the experience gained in the SNAP 10A Program are reviewed and their applications projected to SNAP 10A and 10A-type direct radiating thermoelectric power systems. This report presents these applications to the existing SNAPSHOT-1 spare system and to new systems using newly developed high-temperature thermoelectric converter components coupled with the existing SNAP 10A-2 reactor and advanced reactor concepts. The areas discussed include the recommended modifications to the SNAPSHOT-1 spare system; design of an optimized SNAP 10-A-type system; and design of an advanced direct radiating thermoelectric system employing both the advanced thermoelectric and reactor components. (auth)

**2868** (NP-16339) THEORETICAL PERFORMANCE OF ROCKET ENGINES USING GASEOUS HYDROGEN IN THE IDEAL STATE AT STAGNATION TEMPERATURES UP TO 200,000 R. Report No. E-910093-30. Roback, R. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Oct. 1966. Contract NASw-847. 215p.

Theoretical performance parameters for rocket engines utilizing normal gaseous hydrogen in the ideal state were calculated using two different assumptions: first, that the chemical composition remained in equilibrium during the isentropic expansion through the engine exhaust nozzle; and, second, that the chemical composition remained fixed (frozen) during the expansion. Data are presented for stagnation temperatures ranging from 5000 to 200,000°R, stagnation pressures ranging from 1 to 2000 atm, and ratios of exhaust pressure to stagnation pressure ranging from 1 to $10^{-7}$. The following performance parameters were calculated as a function of the ratio of nozzle exhaust pressure to stagnation pressure: temperature, enthalpy, entropy, molecular weight, density, velocity, Mach number, specific impulse and ratio of nozzle-exit area to throat area. Also calculated were several other properties of the gaseous mixture at the throat of the nozzle, such as the weight flow per unit area and a throat flow parameter defined as the product of the weight flow per unit area at the throat and the square root of the stagnation temperature divided by the stagnation pressure, $(W\sqrt{T_T}/A^*P_T)$. (auth)

**2869** (USNRDL-TR-1046) RADIONUCLIDE RELEASE FROM AEROSPACE NUCLEAR REACTOR FUELS. V. PHASE TWO: PULSED NEUTRON IRRADIATION OF FUEL IN WATER. Weisbecker, L. W.; Lai, M. G.; Goya, H. A.; Cordova, H. I. (Naval Radiological Defense Lab., San Francisco, Calif.). May 24, 1966. Contract AT(49-5)-2084. 64p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Accidental seawater immersion of a NERVA/ROVER type core would result in a criticality excursion, releasing fission product radionuclides to the environment. In order to simulate the excursion situation and to study the resulting radionuclide release, specimens of NERVA/ROVER fuel were irradiated under different pulsed neutron conditions in a TRIGA Mark F reactor, the KEWB reactor, and the KIWI-TNT reactor excursion test. Most of these specimens were irradiated immersed in water. Under these conditions, measurements were made of (1) the fission product inventories of fuel specimen and environmental water, (2) internal capsule pressure generated, (3) fuel body and microstructure damage, and (4) leaching properties of irradiated fuel. Irradiation effects of greater than moderate significance occurred only in the fuel specimen irradiated most severely in the KIWI-TNT reactor excursion test. Release of fission products to the water appeared to be a function of exposed surface area of the fuel and was less dependent on specimen specific fissioning for both long-term leaching after irradiation and during irradiation. Fission product fractionation in the fuel was a function of the specimen specific fissioning. All fission products which fractionated, except $^{131}I$, have a volatile precursor. (auth)

**2870** NUCLEAR RAMJET. Lang, Hermann; Radebold, Reinhart (to Licentia Patent-Verwaltungs GmbH). German Patent 1,220,944. July 14, 1966. Filed Aug. 17, 1963.

The nuclear ramjet consists of an inlet diffuser followed by a single-pass, straight through heat exchanger (nuclear reactor core) and an exhaust nozzle. In passing through the core the liquid working medium is evaporated. The vapor is condensed in the region between the core and the exhaust nozzle. The condensation is effected by adding liquid working medium. (Gmelin Inst.)

## Process Heat and Desalination Reactors

**2871** (ORNL-TM-596) ESTIMATED LARGE-SCALE PRODUCTION COSTS FOR CLADDING URANIUM METAL FUEL TUBES. Beaver, R. J. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 40p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Reactor systems considered for economic desalination of sea water appear to be in the range of 3500 to 100,000 MW(t). The magnitude of natural U burned per yr makes the cost of fuel elements a significant consideration. One of the fuel element designs being proposed consists of two concentric U tubes clad with Zircaloy-2. An economic study was undertaken to compare costs of fabricating fuel tubes containing metallic U by coextrusion and pressure bonding using Al and Zircaloy cladding. Fabrication costs for Zircaloy-2-clad tubes ranged between $1.22 and $6.17/lb U charged to the reactor. The higher costs were associated with 3500-MW systems, which have the lowest fuel throughput considered. Al-clad tubes were cheaper, the cost of the fuel tube per lb U charged to a 100,000-MW system being approximately $0.74 compared with $1.26 for similarly fabricated Zircaloy-2-clad tubes. Pressure bonding appears amenable as a technique for cladding Zircaloy-2 as well as Al to U tubes. Thus, one plant would have the capability of manufacturing both Al- and Zircaloy-2-clad tubes. (auth)

## Research and Test Reactors and Critical Assemblies

*Refer also to abstracts 1925, 2819, and 2864.*

**2872** (AD-635041) THE MAXIMUM FUEL ELEMENT LOADING OF THE AIR FORCE NUCLEAR ENGINEERING TEST FACILITY. Terry, Phillip Arthur (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering). Mar. 1966. 205p. (GSP/PH-66-19). CFSTI $6.00 cy, $1.25 mn.

Thesis.

The maximum fuel element loading for the third core of the Air Force Nuclear Engineering Test Facility was calculated. The effects of several fuel element loadings were evaluated using a two-dimensional, burn-p code on the 7094 computer. The criteria used in the evaluation were limits on the excess reactivity, the thermal stress, and the materials of the reactor. The 250-g fuel element loading was found to be the maximum fuel element loading for the third core. (auth)

**2873** (AE-248) ONE-GROUP PERTURBATION THEORY APPLIED TO SUBSTITUTION MEASUREMENTS WITH VOID. Persson, R. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Sept. 1966. 22p. Dep. mn.

Formulas suitable for evaluating progressive as well as single-rod substitution measurements are derived by means of one-group perturbation theory. The diffusion coefficient may depend on direction and position. By using the buckling concept expressions can be derived which are simple and the perturbed flux can be taken into account in a comparatively simple way. By using an unconventional definition of cells, a transition region is introduced. Experiments with 3.05 cm-dia voids around metal rods were analyzed. The agreement between extrapolated and directly measured buckling values is excellent, the buckling difference between lattices with water-filled and voided shrouds being $0.263 \pm 0.015$ $m^{-2}$ and $0.267 \pm 0.005$ $m^{-2}$ respectively. From single-rod experiments differences between diffusion coefficients are determined to $\delta D_r/D = 0.083 \pm 0.004$ and $\delta D_z/D = 0.120 \pm 0.018$. With air-filled shrouds there is anisotropy in the neutron diffusion and the values $(D_z/D_r)_{air} = 1.034 \pm 0.020$ are valid. (auth)

**2874** (APDA-188) EVALUATION OF THE NEED FOR A NUCLEAR PROOF TEST FACILITY FOR THE FAST FLUX TEST FACILITY. Wehmeyer, David B. (Atomic Power Development Associates, Inc., Detroit, Mich.). Apr. 30, 1966. Contract AT (11-1)-865. 31p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The evaluation study of the Proof Test Facility (PTF) looked a the capabilities of the PTF, determined the experimental program and nuclear information necessary for correct operation of the Fast Test Reactor (FTR), and estimated the economic trade-off between PTF cost and the cost of performing the experiments on the FTR itself. Time estimates were made for the experimental determinations, important operating characteristics of the PTF were calculated based on the proposed FTR design, and a set of function and design requirements for the PTF were determined. The accuracy and usefulness of information obtainable using the PTF was estimated from experience in relating ZPR critical experiment data to the Fermi reactor operation. Using this background information, a detailed set of recommendations was adopted. (auth)

**2875** (IN-1022) THE TRA SAFEGUARD COMMITTEE. Nertney, R. J. (Idaho Nuclear Corp., Idaho Falls). Sept. 1966. Contract AT(10-1)-1230. 12p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The working charter of the TRA Safeguard Committee is presented. It describes the duties and functions of the TRA Safeguard Committee; documents certain existing procedures regarding reactor and experimental safety at the MTR, ETR, and ATR; indicates those activities which require TRA Safeguard Committee approval; describes the procedures for obtaining such approval; and relates the activities of the TRA Safeguard Committee to the functions and responsibilities of Idaho Nuclear Corporation line supervision. (auth)

**2876** EXPERIMENTAL OBSERVATIONS WITH A SEMICONDUCTOR COMPTON SPECTROMETER DURING BURNUP MEASUREMENTS ON FUEL ELEMENTS. Buba, L.; Hick, H.; Rumpolu, K. (Oesterreichische Studiengesellschaft fuer Atomenergie, Seibersdorf, Austria). Acta Phys. Austr., 23: 215-22(1966). (In German).

The measurement results were tested by independent methods such as neutron physics measurements and calculations and by destructive chemical and mass spectrometric analyses. For a MTR element of the ASTRO reactor good agreement (4%) was established within an estimated error of $\sigma = 12\%$. For a plate of the Brookhaven Graphite Reactor divided into 18 parts an agreement of 0.5% was measured for the sum of 10 analyzed fragments. The agreement of the measured values for the individual fragments was 6.4% on an average, which must be ascribed to diffusion of Cs or Xe. (tr-auth)

**2877** RADIATION SAFETY AT THE UNIVERSITY OF VIRGINIA. Meem, J. L. Nucl. Safety, 7: 292-6(Spring 1966).

The organization for radiation safety at the University of Virginia is described. The radiation-safety program is applied to the nuclear reactor, the particle accelerators, and the two large cobalt sources at the University of Virginia Hospital and at Blandy Experimental Farm. Radiation safety is administered by a Radiation Safety Committee and a Reactor Safety Committee under license with the Atomic Energy Commission. Self-regulation under rather broad limits has been established. (auth)

**2878** DOPPLER EFFECT IN FAST REACTORS. Preskitt, C. A. Nucl. Safety, 7: 313-18(Spring 1966).

The physics of Doppler effects in fast reactors is reviewed. The recent increased importance of the Doppler effect is related to characteristics of ceramic-fueled reactors not present in the earlier metal-fueled systems. Comparisons are made with thermal reactors in discussing the influence of the reactor spectrum and the necessity for a basically statistical approach to the problem. (auth)

**2879** FEW GROUP DIFFUSION CALCULATIONS OF A LIGHT WATER MODERATED LATTICE. Mizuta, Hiroshi; Makino, Kakuji. J. Nucl. Sci. Technol. (Tokyo), 3: 309-19 (Aug. 1966).

An analysis was made of a light water moderated lattice based on few group diffusion calculations. The lattice under investigation consisted of 468 fuel rods in a square lattice arranged in a cylindrical core of 22.46 cm effective radius and 127.2 cm core height, with a water to fuel volume ratio of 2.918. The fuel was 2.02% enriched $UO_2$, clad in 0.8 mm thick Al tube. The theoretically calculated values for thermal, epithermal and fast neutron flux distributions, as well as the effective multiplication constant $\lambda$ of the lattice, were compared with experimental data. After detailed analysis of the problems encountered in the course of the study the value of 0.9935 was determined for $\lambda$. Uncertainty in the nuclear data for fast neutrons would appear to constitute the greatest factor of error in $\lambda$. The discrepancies between the calculated and experimental activation distributions of the thermal, epithermal and fast neutrons amount to about 20, 10, and 15%, respectively, in the reflector region adjoining the core. The fact that these discrepancies cannot be removed by multigroup $P_1$ calculations would point toward insufficiency of the diffusion or $P_1$ calculation in this region. (auth)

**2880** LARGE FAST PLUTONIUM BREEDERS WITH NON-URANIUM PLUTONIUM SOLVENTS. Leipunskii, A. I.; Kazachkovskii, O. D.; Shikhov, S. B.; Yurova, L. N.; Khromov, V. V.; Shmelev, A. N.; Sukhoruchkin, V. K. At. Energ. (USSR), 21: 84-92(Aug. 1966). (In Russian).

The physical characteristics of fast breeder reactors with cylindrical and annular active zones were investigated along with the characteristics of infinite lattices of heterogenically distributed large fuel assemblies in the breeder zone. Calculations were made for a hypothetical Pu solvent with nuclear density $3 \times 10^{22}$ nuclei/cm$^3$ using UC for the breeding material. (tr-auth)

**2881** INFLUENCE OF RESEARCH REACTOR PARAMETERS ON THERMAL NEUTRON FLUX IN A REFLECTOR AND FUEL INVENTORY. Kochenov, A. S. At. Energ. (USSR), 21: 97-101 (Aug. 1966). (In Russian).

The effects of experimental reactor parameters on the thermal neutron flux magnitude in a reflector and the cost of fuel were evaluated. It is shown that the larger the neutron breeding coefficient and the smaller the active zone radius, the higher the ratio of the thermal neutron maximum flux to the reactor capacity. The ratio is sufficiently high in the case of a water-water type reactor operating with intermediate neutrons. It is shown that neither too low nor too high fuel burnup is economical for the experimental reactor. (R.V.J.)

**2882** DIGITAL FOLLOW-UP SYSTEM FOR NUCLEAR ENGINEERING. Kovanits, Pavel; Rygl, Yaroslav. At. Energ. (USSR), 21: 116-20(Aug. 1966). (In Russian).

A generalized block-diagram of a digital follow-up device for measuring relative pulse count deviation from the assigned is presented. The device is used as a follow-up system in a pulse detector for measuring and automatically regulating the reactor power and cycle operations. (R.V.J.)

**2883** SUBCRITICAL REACTIVITY DETERMINATIONS: COMPARISON OF EXPERIMENTAL METHODS. Gozani, Tsahi (Rensselaer Polytechnic Inst., Troy, N. Y.). 5p. (CONF-660606-25). ORAU. Gmelin, AED-CONF-66-203-82.

From American Nuclear Society Meeting, Denver, Colo.

A discussion and comparison are presented of basic subcritical methods for reactivity measurements. The merits of the kinetic methods applied are the possibility of measuring large reactivities without safety problems, rapidity of obtaining data, and the results and good reproducibility. (J.C.W.)

**2884** EXPERIMENTAL STUDIES OF MIXED $D_2O$ LATTICES CONTAINING $ThO_2$ RODS. Sokolowski, E.; Andersson, A. J. W.; Persson, R.; Wikdahl, C. E. (Aktiebolaget Atomenergi, Stockholm). 17p. (CONF-660524-23). ORAU. Gmelin, AED-CONF-66-104-18.

From 2nd International Thorium Fuel Cycle Symposium, Gatlinburg, Tenn.

Measurements were made on $D_2O$ lattices of natural $UO_2$ rods, 1.2% enriched $UO_2$ rods, $ThO_2$ rods, and their admixtures. The data from the buckling, spectral index, and flux distribution measurements are presented. Conversion ratio measurements were also made. (D.L.C.)

**2885** INTERPRETATION OF PULSED-SOURCE EXPERIMENTS IN A REFLECTED REACTOR. Waltar, Alan E.; Ruby, Lawrence (Univ. of California, Berkeley). 15p. (CONF-660606-35). ORAU. Gmelin, AED-CONF-66-203-59.

From American Nuclear Society Meeting, Denver, Colo.

An explanation of the departure of the pulsed-source response curve from a simple exponential for a two-region system is presented. In addition, a new method is proposed for calculating the reactivity based on the two-region model of C. E. Cohn. It is shown that the reactivity, which is defined somewhat differently from the choice made by Cohn, can be computed from either core or reflector data. Preliminary experimental results from the AGN-201 Reactor are cited in support of the theory. (auth)

**2886** SAFETY COUPLING FOR A ROTATING WHEEL WHICH PRODUCES PULSES IN THE REACTIVITY OF FAST NUCLEAR RESEARCH REACTORS. Hanke, Wilhelm (to EURATOM). German Patent 1,223,962. Sept. 1, 1966. Filed Feb. 15, 1965.

A device for the production of pulses in the reactivity of a fast nuclear reactor comprises a rotatable wheel extending into the core region and carrying on its periphery fuel or reflector material. The wheel is mounted on a shaft by means of a screw thread

on the outer surface of the shaft. On sudden blocking of the rotating shaft, the wheel, which is normally secured on the shaft by means of a breaking bolt, starts rotating relative to the shaft thus being screwed away from the reactor core along the shaft. Means are provided for gradually absorbing the energy of rotation of the wheel. (Gmelin Inst.)

**2887** DEVICE FOR ADJUSTING AUTOMATICALLY THE PRESSURE OF A HEAT-INSULATING GAS IN A PRESSURE-TUBE TYPE REACTOR. Nakanishi, Tetsuichiro (to Hitachi Shipbuilding and Engineering Co., Ltd.). Japanese Patent 1965-26079. Nov. 12, 1965. Filed Aug. 25, 1962.

An automatic device for adjusting the pressure of a heat-insulating gas is proposed for use in pressure-tube reactors using water, steam or gas as the coolant. With this device, the pressure of the heat-insulating gas can be adjusted safely and effectively, corresponding to the variation in the pressure of the coolant, in the reactor from startup to shutdown. Between the inner surface of a pressure tube and the coolant flowing through the tube is provided a heat-insulating gas layer in the shape of a thin-walled cylindrical body (the layer and the flowing coolant are separated by the thin wall of a cylindrical body). The difference between the pressure of the heat-insulating gas and of the coolant is indicated by the movement (or position) of a piston, which is in the automatic pressure-adjuster. By means of an "isotope slit" or "electrical contactor," connected with the movement of the piston, the gas compressor is started or stopped, thereby constantly keeping the pressure of the coolant and of the heat-insulating gas at the same value. (NSA of Japan)

**2888** SYNCHRONIZED CONTROL-ROD POSITION INDICATOR FOR THE REACTOR-CONTROL MECHANISM. Inoue, Tatsunosuke (to Hitachi Ltd.). Japanese Patent 1965-25480. Nov. 6, 1965. Filed June 16, 1962.

The synchronized control rod position indicator proposed is capable of indicating the exact position of a control rod, without affecting the indicator mechanism, when the control rod undergoes a transient movement. The respective circuits connecting the signal transmitter and the receiver are installed in parallel with circuits which have an adjusting resistance for giving such torques, that in the abrupt reactor change (e.g., the scram), the receiver is not operated. In the normal reactor condition, it is operated. In the normal reactor operation, the transmitter and the receiver are directly connected, but in the reactor scram it is automatically switched to the circuits with the adjusting resistance, thereby protecting the receiver. When the scram is complete, an indication is given of the exact position of the control rod. (NSA of Japan)

**2889** DEVICE FOR LOADING AND UNLOADING HORIZONTAL EXPERIMENTAL HOLES IN RESEARCH REACTORS. Pollermann, Max (to Kernforschungsanlage). German Patent 1,223,069. Aug. 18, 1966. Filed Oct. 4, 1963.

The device consists of a horizontal casket suspended from a movable crane by means of three cables each of which is provided with means for varying its length. A structure in front of the hole and attached to the reactor facilitates the horizontal adjustment of the casket by means of three adjusting screws. (tr-auth)

## Production Reactors

*Refer also to abstract 1328.*

## Reactor Components, Fuels and Accessories

*Refer also to abstracts 1312, 1506, 1696, 1911, 1916, 1926, 1927, 1935–1937, 1940, 1956, 1962, and 1963.*

**2890** (CONF-661003-9) URANIUM OXIDE FUEL FOR THERMIONIC ENERGY CONVERSION. Grossman, L. N. (General Electric Co., Pleasanton, Calif. Nuclear Technology Dept.). [1966]. Contract AT(04-3)-189. 24p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From AIME Nuclear Metallurgy Symposium on High Temperature Nuclear Fuels, Delevan, Wis.

Nuclear thermionic fuel elements that use $UO_2$ fuel clad with refractory metal emitters operate at high temperatures for long periods of time. Hyperstoichiometric $UO_2$ loses $O_2$ as $UO_3$(g) when free evaporation is allowed. When tightly clad in W, small amounts of excess $O_2$ in the $UO_2$ escape the W as $O_2$(g). When sufficient excess $O_2$ is present (O-to-U ratios greater than about 2.01), gaseous W (or Mo) oxides escape the cladding surface. Stoichiometric $UO_2$ evaporates principally as $UO_2$ (g). Stoichiometric urania clad in W loses $O_2$ at high temperatures by diffusion through the cladding and evaporation of $O_2$(g). The evaporation of $UO_2$ at 1700 and 1900°C into a semi-infinite volume is suppressed by a factor of about 100 by Cs gas at 4 torr. The evaporation rate of $UO_2$ also has been observed to be suppressed by Ar cover gas at 10 torr and 1750°C with a cold collector 0.050 in. removed. Thermal cycling of stoichiometric $UO_2$ at 1600 to 2200°C (for W), and 1450 to 1750°C (for Mo) revealed a small enhancement of U flux through the cladding after cycling. The observed U flux through W and Mo is typically about $10^{-10}$ gm-hr$^{-1}$-cm$^{-2}$, with peaks of $10^{-9}$ to $10^{-8}$ gm-hr$^{-1}$-cm$^{-2}$. (J.R.D.)

**2891** (EUR-3071.d) DIE MESSUNG DES ABBRANDZUSTANDES KUGELFOERMIGER BRENNELEMENTE MIT HILFE EINES HOCHAUFLOESENDEN HALBLEITERGAMMASPECKTROMETERS. (Burnup Measurement on Spherical Fuel-Elements by Means of a High-Resolution Semi-Conductor: Gamma Spectrometer). Bueker, H. (Brown Boveri/Krupp Reaktorbau G.m.b.H., Duesseldorf (West Germany). Kernforschungsanlage, Juelich (West Germany)). Aug. 1966. 38p. Dep. mn.

A description is given of a method of measuring the burnup level of spherical fuel elements. A non-destructive and rapid burnup determination is obtained by means of $\gamma$ spectrometry. The measuring apparatus is a high-resolution photo-peak $\gamma$ spectrometer equipped with a Li-drifted Ge semiconductor detector. The $^{137}Cs$ photo-line at 662 keV serves as a reference line for measurement. Its intensity provides a measurement of the burnup. The first measurements were carried out on a fuel sample. (auth)

**2892** (EUR-3076.e) BACCHUS: A BURN-UP CODE FOR CONTINUOUS CHARGE-DISCHARGE FUEL CYCLES. Massimo, L. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 10p. Dep. mn.

The Bacchus code has been developed to calculate continuous charge-discharge fuel cycles in various reactor types with different fuels, including cases where the neutron spectrum is strongly distorted as for instance with Pu fuel in undermoderated reactors. Because of this reason, the spectrum calculation is performed with 68 fast and 96 thermal groups according to the methods developed by General Atomic. The fine structure of the flux in the cell can be taken into account with previously calculated concentration-dependent self-shielding factors. The code can deal with fuel reprocessing and seed and breed concepts. Up to 50 isotopes can be treated separately in the burnup equations. The most important feature of this code is the possibility of considering self-shielding variations during the fuel element life time. This made difficult an analytical solution of the burnup equations, so a numerical solution by finite-difference approximation has been used. Typical results are discussed for the case of Pu–Th fuel cycles in High Temperature Graphite Reactors with particular attention to the effects of self-shielding variation. (auth)

**2893** (HW-83439) OXYGEN CONTROL IN LOW-TEMPERATURE, PRESSURIZED WATER REACTOR SYSTEMS. Demmitt, T. F.; FitzPatrick, V. F. (General Electric Co., Richland, Wash. Hanford Atomic Products Operation). July 27, 1964. Contract AT(45-1)-1350. 9p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The coolant in pressurized water reactor systems undergoes radiolytic decomposition to $H_2$ and $O_2$ gases with $H_2O_2$ as an intermediate. The reaction products accumulate in the coolant at temperatures below about 150°C unless reducing agents are present to react with them. Hydrazine is normally added for this purpose in systems operating below 100°C while $H_2$ gas is added at higher temperatures. Recent studies indicate that reducing species formed by irradiation of pH 10 ammoniated coolants satisfactorily retard coolant radiolysis at temperatures as low as 70°C. Hydrazine could be the primary species involved, but other activated materials or unstable species with lifetimes too short to permit measurement could also be very important. The major disadvantages of using $NH_4OH$ for this application are gas generation and selective corrosion of Cu alloys present in the system. (auth)

**2894** (IN-1017) COMPUTER CODE FOR THE CALCULATION OF FUEL AND POISON CROSS SECTIONS FROM REACTIVITY MEASUREMENTS. Nisle, Robert G.; Peereboom, R. A.; Aller, D J.; Anderson, K. J. (Idaho Nuclear Corp., Idaho Falls). Aug. 1966. Contract AT(10-1)-1230. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Transient reactivity measurements on irradiated fuel samples provide a means for measuring fuel content and gross fission product cross sections by a nondestructive method. When an appreciable amount of self-shielding is present, the reactor response is no longer a linear function of content. In that case the pertinent equations involve algebraic and exponential terms. Hence an iterative procedure must be used. This program, therefore, solves for fuel and poison content by means of a double iteration for fuel cross section and for poison cross section by the use of reactivity measurements made in two measuring locations having different

relative worths for neutron absorption (primarily thermal) and for neutron production. (auth)

**2895** (JUL-357-RG) EINE EINFACHE ANORDNUNG ZUR FESTSTELLUNG VON FORMAENDERUNGEN ELEKTRISCH LEITENDER KUGELN. (A Simple Arrangement for the Establishment of the Form Changes of Electrically Conducting Spheres). Hecker, R. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorentwicklung). Feb. 1966. 21p. Dep. mn.

An automatic device for the determination and measurement of the form changes of electrically conducting spheres exposed to reactor irradiation is described. The damage detection is based on the relation between the denting of the surface and the extent of the damage and on the orientation of the damage site to the coil axis. (J.S.R.)

**2896** (TID-6506(Pt.3) (4th Ed.)) SUMMARIES OF FAST REACTOR FUELS AND MATERIALS DEVELOPMENT PROGRAMS. Norman, Edgar C. (ed.) (Division of Reactor Development and Technology (AEC), Washington, D. C.). May 1966. 259p. Dep. mn. CFSTI $6.00 cy, $2.25 mn.

Research on fuels and materials in support of the Liquid Metal Fast Breeder Reactor Program is summarized. Sections are included on work at Argonne, Atomics International, Battelle, Brookhaven, General Electric, Los Alamos, MSA Research, Monsanto, Nuclear Materials and Equipment Corp., ORNL, United Nuclear Corp., and Westinghouse. (J.R.D.)

**2897** (TRG-Report-933(Pt.2)) STANDARD RELAY MODULES FOR SAFETY AND CONTROL CIRCUITS. PART 2. INSTRUCTION AND MAINTENANCE MANUAL. Maple, B. J.; Cooper, A. G. (Reactor Group, United Kingdom Atomic Energy Authority, Risley (England)). Mar. 21, 1965. 60p. Dep. BIS $1.80. HMSO 9s.

Standard relay modules have been designed to meet the need for relay logic on experimental plant. The design can be constructed without prior knowledge of the plant requirements and can be made to suit a particular application by the simple expedient of arranging links in a removable connector. (auth)

**2898** A VERSATILE FAIL-SAFE TRIP CIRCUIT FOR REACTOR SAFETY SYSTEMS. **Trenholme, William; Keefe, Donald J.; McDowell, William P. (Argonne National Lab., Ill.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-13: No. 5, 6-7(Oct. 1966).**

A transistorized trip circuit is described which employs a simple self-testing technique to achieve a high degree of fail-safeness with a minimum number of components. It operates with dc input currents in the range from 10 to 100 microamperes and can control up to 100 watts of load power. The trip differential for a load change from full power to zero power is less than 0.1 microampere; and the temperature stability of the trip point is better than 0.02 a/°C. This trip circuit may be used with either relay or solid-state logic and power switching circuits. (auth)

**2899** FUEL-ELEMENT PERFORMANCE LIMITATIONS. Scott, J. L. Nucl. Safety, 7: 302-13(Spring 1966).

A key aspect of the evaluation of the safety of a nuclear reactor is the proper assessment of fuel-element performance limitations. Recent information that either extends or more clearly establishes performance limitations for both metal and ceramic fuels is reviewed. (auth)

**2900** VITAL POWER SUPPLIES FOR NUCLEAR FACILITIES. Rubel, Paul. Nucl. Safety, 7: 324-8(Spring 1966).

Means for evaluating power supplies for vital functions in nuclear facilities are discussed. The overall system for supplying power for vital functions must be examined so that the power-supply reliability can be evaluated according to requirements consistent with those of the vital functions served. The application of the general system-reliability criteria of redundance, independence, isolation, and testing is suggested. Other design, maintenance, and administrative aspects of power systems are correlated. (auth)

**2901** REACTOR MATERIALS. Volume 9, Number 2. Dayton, R. W.; Simons, E. M.; Endebrock, R. W. (eds.). Contract W-7405-eng-92. One of the five Quarterly Technical Progress Reviews published for the Division of Technical Information, USAEC. Battelle Memorial Inst., Columbus, Ohio, Summer 1966. 77p. GPO $0.70 Domestic, $0.90 Foreign.

Significant developments in the properties, behavior, and fabrication processes of materials applicable to nuclear reactor components and associated equipment are reviewed. Separate abstracts were prepared for 10 individual topics. (H.D.R.)

*For abstracts of individual papers see: 1868, 1878, 1879, 1897–1901, 1922, and 2902.*

**2902** FUEL AND FERTILE MATERIALS. Reactor Mater., 9: 73-90(Summer 1966).

The development of U metal and alloys, Pu, Pu compounds, metal-ceramic fuels, coated-particle fuels, U oxide fuels, and U and Th carbides, nitrides, sulfides, and phosphides is reviewed. Irradiation effects in fuel materials are also discussed. (H.D.R.)

**2903** OPTIMUM WATER QUANTITY IN CONCRETE FOR REACTOR SHIELDING. Zaitsev, L. N.; Komochkov, M. M. Sb. Tr. Mosk. Inzh.-Stroitel. Inst., 41: 33-44(1962). (In Russian).

In the design and construction of concrete shields it is desirable to look for that concrete which corresponds in composition to the optimum conditions for volume weight and water concentrations. The optimum quantity of water in the concrete is not constant but is in complex dependence on the volume weight of the concrete, attenuation factors, and ratios indicating how much the $\gamma$ radiation exceeds the neutron flux. In the majority of concrete shields for nuclear reactors, the quantity of water required varies from 2 to 6% by weight. The use of coatings to protect the concrete from moisture diffusion determines not only the temperature gradients in the shield but the physical conditions calling for the use of one or another type of concrete. The dependence of the water content of the concrete and the total weight permits a very flexible approach to the selection of the concrete composition that can give the optimum engineering economic results. The results of the study are not complete or accurate, and the interpretation of the data for other classes or forms of shielding must be done with great care. (tr-auth)

**2904** CONTROL DEVICE FOR NUCLEAR REACTORS. Mostert, Pieter (to Samenwerkende Electriciteits-Produktiebedrijven, NV). German Patent 1,219,598. June 23, 1966. Priority date June 4, 1962, Netherlands.

The control device comprises a plurality of vertically arranged tubes within the reactor core containing a neutron absorbing liquid and communicating with tanks located outside of the reactor vessel. The free surface of the absorbing liquid in the tanks is subjected either to a variable and relatively small pressure from a first compressed gas tank in order to change the level of the liquid in the tubes, the upper extremity of which is shut, or to a high pressure from a second compressed gas tank so that the tubes are completely filled up with the liquid, thus stopping the reactor. The control fluid is periodically refined by means of a separate circuit. (tr-auth)

**2905** FUEL ELEMENT FOR A NUCLEAR REACTOR. Hildebrand, Goesta Erik (to Fulcrum Aktiebolag). German Patent 1,220,942. July 14, 1966. Filed Mar. 12, 1962.

A fuel element for a nuclear reactor comprises a central core of fissile material capable of withstanding the high temperatures prevailing in the central part of the fuel element during operation, an outer mantle of fissile material and an intermediate layer of non-fissile material for transferring heat from the core to the mantle. The non-fissile material is of low neutron absorption cross-section and chemically inert towards the fissile material. The core is of higher thermal stability than the mantle and the mantle of higher thermal conductivity than the core. The non-fissile material is either a gas (Ar, He, $H_2$) or a Pb–Bi or NaK eutectic alloy. (auth)

**2906** DEVICE FOR CONTROLLING NUCLEAR REACTORS. Edlund, Milton Carl; Schluderberg, Donald Carroll (to Babcock and Wilcox Co.). German Patent 1,221,373. July 21, 1966. Priority date Dec. 8, 1961, United States.

A nuclear reactor comprises a separate circuit through the core through which a mixture of $H_2$-containing vapor and a gas (He, $CO_2$) is circulated, the $H_2$ content of which is varied. (tr-auth)

**2907** MOUNTING DEVICE FOR FUEL ELEMENT ASSEMBLIES IN A NUCLEAR REACTOR. Hespel, Claude; Olivier, Joseph (to Commissariat a l'Energie Atomique). German Patent 1,220,044. June 30, 1966. Priority date Oct. 14, 1960, France.

The mounting device comprises a head and a cylindrical guide tube. The head is located in a recess in the upper grid of the reactor and has at its upper part a collar member forming an abutment, in which the head is of parallelepiped shape having a vertical axis, machined along its axis and provided at its lower part with apertures for receiving pawls pivoted about horizontal axes. The cylindrical guide tube is partly introduced into the machined-bore of the head and moves the pawls into contact with the lower edge of the recess, locking means provided between the head and the guide tube and the ends of the fuel element secured by means of flanges to the lower part of the head and to a ferrule member freely slidable in a recess in the reactor lower grid. (tr-auth)

**2908** METHOD OF DERIVING A SIGNAL REPRESENTING THE MOMENTARY POWER OF A NUCLEAR REACTOR. Fishman, Ygal (to Gebrueder Sulzer Aktiengesellschaft). German

Patent 1,221,374. July 21, 1966. Priority date Sept. 19, 1963, Switzerland.

The signal is derived by multiplication of a signal produced by measuring the neutron flux at a point in the reactor by a signal produced in dependence upon the heat output of the reactor. The signal obtained by measuring the neutron flux is continuously corrected by a factor derived by functionally connecting the signal representing the neutron flux with the signal representing the thermal output of the reactor. (tr-auth)

**2909** THERMIONIC CONVERTER FOR NUCLEAR REACTORS. Dudnick, Dietrich; Janner, Karl (to Siemens-Schuckertwerke Aktiengesellschaft). German Patent 1,219,597. June 23, 1966. Filed Nov. 25, 1964.

A thermionic converter comprises a series connection of diodes each of which is constituted with a collector having the shape of a truncated cone and an emitter likewise in the shape of a truncated cone located within the collector and filled with a fissile material. The collectors and the emitters are movable relative to each other along their common axis so that the electrode distance may be varied. (Gmelin Inst.)

**2910** DEVICE FOR CHARGING AND DISCHARGING FUEL ELEMENT CANS FOR NUCLEAR REACTORS. Erb, Emil; Simon, Helmut (to Gesellschaft fuer Kernforschung mbH). German Patent 1,224,413. Sept. 8, 1966. Filed Aug. 1, 1964.

Fuel element cans to be inserted into the core of a nuclear reactor are charged or discharged by means of a mechanical device which comprises a sorting machine classifying the fuel rods and a shifting apparatus which transfers the fuel rods from the sorting machine to the can and vice versa. (Gmelin Inst.)

**2911** FUEL ROD FOR NUCLEAR REACTORS. Kroepfl, Hans (to Siemens-Schuckertwerke Aktiengesellschaft). German Patent 1,225,313. Sept. 22, 1966. Filed Sept. 30, 1964.

A fuel rod for nuclear reactors comprises a cylindrical fuel member enclosed in a protective sheath provided with end caps, spacer discs of insulating material placed between the fuel member and the end caps, and a chamber for collecting the fission gases placed between the end caps and the spacer discs. The collecting chamber is surrounded by an exially resilient tubular member placed within the sheath between the spacer discs and the end caps. (Gmelin Inst.)

**2912** NUCLEAR MODERATOR STRUCTURE. Martin, Roger (to Commissariat a l'Energie Atomique). German Patent 1,219,595. June 23, 1966. Priority date Oct. 18, 1958, France.

A nuclear moderator structure includes a stack of bars of solid moderator material, longitudinal grooves in the bars, profiled connecting members having three arms. Each of the arms receive slight friction in the adjacent groove in the adjacent bar in the same transverse level of the structure. Each arm engages at least two bars in adjacent longitudinal relationship and terminates short of the bottom of its respective groove whereby play is provided compensating for expansion of the structure during use. Transverse distance pieces extend between and bear against adjoining connecting members and carry each bar in the same transverse plane for maintaining predetermined spacing between adjacent bars. (tr-auth)

# GENERAL

**2913** (ANL-7200) RATIONAL CHEBYSHEV APPROXIMATIONS FOR FERMI-DIRAC INTEGRALS OF ORDERS $-\frac{1}{2}$, $\frac{1}{2}$, AND $\frac{3}{2}$. Cody, W. J.; Thacher, Henry C. Jr. (Argonne National Lab., Ill.). May 1966. Contract W-31-109-eng-38. 49p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Rational Chebyshev approximations are given for the complete Fermi-Dirac integrals of orders $-\frac{1}{2}$, $\frac{1}{2}$, and $\frac{3}{2}$. Maximal relative errors vary with the function and interval considered, but generally range down to $10^{-9}$ or less. (auth)

**2914** (ANL-7213) MULTISTEP INTEGER-PRESERVING GAUSSIAN ELIMINATION. Bareiss, Erwin H. (Argonne National Lab., Ill.). May 1966. Contract W-31-109-eng-38. 24p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A method is developed which permits integer-preserving elimination in systems of linear equations, AX = B, such that the magnitude of the coefficients in the transformed matrices is minimized, and the computational efficiency is considerably increased in comparison with the corresponding ordinary (single-step) Gaussian elimination. The algorithms presented can also be used for the efficient evaluation of determinants and their leading minors. Explicit algorithms and flow charts are given for the two-step method. The method should also prove superior to the widely used fraction-producing Gaussian elimination when A is nearly singular. (auth)

**2915** (BNL-976) THE PROBLEM OF DEVELOPMENT. Brookhaven Lecture Series No. 35. Caspari, Ernst (Brookhaven National Lab., Upton, N. Y.). Apr. 15, 1964. Contract AT(30-2)-Gen-16. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

An attempt is made to relate developmental processes in multicellular animals and plants to the state and activity of genetic material inside the cells. It is pointed out that even though all the genes are present in every cell of a multicellular organism, the process of differentiation consists in the activation and repression of different components of the genic complement. Mechanisms for the activation and repression of particular genes and gene products in microorganisms form the basis for enzyme induction, feedback inhibition, and coordinate repression. In multicellular organisms, cells of identical genotype show different chemical and morphological properties and these characters appear in a definite, closely regulated pattern in space and time and it is assumed that these progressive changes in cells and cell groups that appear at different times are under the control of genes. Results are reported from studies on genes that affect eye pigment development in insects and the genetic control of enzyme synthesis involved in the development with emphasis on the meal moth Ephestia, in which eye pigments consist of two different types of compounds, ommochromes and pteridines. Results are reported from studies on the pattern of pigment and enzyme development, the chemical and genetic basis of competence, and the timing of pigment formation and morphogenesis in the eye. It is postulated that the organization of the different genic activities and partial processes into a coordinated pattern may be unique for every species and defy a generalized picture applicable to all organisms. (C.H.)

**2916** (K-1641) TWO ALGORITHMS FOR COMPUTING THE GENERALIZED INVERSE OF A MATRIX. Rust, Bert Woodard (Oak Ridge Gaseous Diffusion Plant, Tenn.). Nov. 9, 1966. Contract W-7405-eng-26. 41p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Thesis. Submitted to Univ. of Tennessee, Knoxville.

The computation of generalized inverses of arbitrary mxn complex matrices is considered. Two methods are discussed and both of them are extensions of well-known methods for inverting nonsingular matrices. The first method is based upon the factorization of the matrix which is obtained by orthogonalizing its columns by the Gram-Schmidt process. The second method is based upon a factorization of the matrix obtained by using elementary Hermitian matrices. The use of these techniques for inverting non-singular matrices is first explained and then their extensions to arbitrary mxn matrices is given. (auth)

**2917** (KAPL-P-3178) USE OF FORTRAN INTERPRETIVE PROGRAMS AT THE KNOLLS ATOMIC POWER LABORATORY. Mueller, Gerhard O. (Knolls Atomic Power Lab., Schenectady, N. Y.). Sept. 1966. Contract W-31-109-eng-52. 8p. (CONF-661024-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Control Data Corporation Users Group VIM V Conference, Dallas, Texas.

The use of FORTRAN interpreted programs, which are a collection of general purpose routines that enable the computer to solve large variety of problems by the simple manipulation of basic input instructions, at the Knolls Atomic Power Laboratory is discussed. (B.G.D.)

**2918** (NP-16366) ATOMIC ENERGY BOARD NINTH ANNUAL REPORT, 1965. (Atomic Energy Board, Pelindaba, Pretoria (South Africa)). 72p. Dep. mn.

Research progress on geology, extraction metallurgy, reactor engineering, physical metallurgy, chemistry, physics, isotopes and radiation, and life sciences is reported. Financial aid, technical activities, liaison and information affairs, and handling and control of radioactive material are discussed. (M.C.G.)

**2919** (ORNL-TM-1635) CIVIL DEFENSE VIEWED AS A PROBLEM IN SOCIAL INNOVATION. Dexter, Lewis A. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 18p. (CONF-660555-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From National Meetings of The Society for Applied Anthropology, Milwaukee, Wis.

Institutional, organizational, and political changes necessary to increase the chances of survival and recovery if attacked with nuclear weapons are discussed. These changes demand political innovations and reorientation of attitudes and principles. Civil defense planning program needs for implementation, including training for shelter seekers, for shelter managers, and in shelter living are stressed. (F.S.)

**2920** (ORO-3195-8) PASSIVE IMMUNOTHERAPY OF CANCER. Day, Eugene D. (Duke Univ., Durham, N. C.). May 13, 1966. Contract AT(40-1)-3195. 13p. (CONF-660525-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Critique for Use by the Scientific Group on Immunotherapy of Cancer, World Health Organization, Geneva, Switzerland.

Problems involved in the immunotherapy of cancers are reviewed. Data are summarized from measurements of the degree of anaplasia of carcinomas of 11 different organs in 49 specimens and their associated immunological reactivity with anticancer antisera. It is postulated that a specific immune attack against cancer may in essence be a specific immune attack against an endogenous cell regulator clone that would result in increased anaplasia of the tumor, increased compatibility, increased rate of growth, increased ability to metastasize, and increased ability to kill the host. The question of communal and private cancer antigens is discussed. It is pointed out that if viral induced tumors contain communal cancer-specific antigens and chemically induced tumors contain private antigens some assay methods will reveal private antigens but cover up the possible communal antigens that also exist in these tumors. It is concluded that a communal type of antigen will offer more promise for cancer immunotherapy than private antigens. (C.H.)

**2921** (SC-RR-260) AN EXPERIMENTAL INVESTIGATION OF THE CONTINUOUS PENETRATION OF A BLUNT BODY INTO A SIMULATED COHESIONLESS SOIL. Colp, John L. (Sandia Corp., Albuquerque, N. Mex.). Dec. 1965. Contract AT(29-1)-789. 76p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Constant velocity experiments were performed to investigate the penetration of a blunt body into a two-dimensional granular target medium having no cohesion. The mechanism of continuous penetration at constant velocity was compared with present soil ultimate strength theory (used to predict the failure of a statically loaded footing). The study was also designed to determine how penetration velocity and penetrator width affect resistance to continuous penetration and to determine if the Prandtl-Terzaghi formula for bearing capacity could be used to compute the resistance to penetration of a projectile into a granular cohesionless material. The target material used in the experimental study consisted of many thousands of precision ground steel rollers of 3 diameters ($\frac{1}{16}$, $\frac{3}{32}$, and $\frac{1}{8}$ inch) stacked in a target tank having one transparent face. One-, two-, and three-inch wide penetrators were used at four different, constant velocities. Both the unit and the total load on the penetrator decreased as the velocity of penetration increased. Unit loads on the penetrator decreased as penetrator width was increased. The Prandtl-Terzaghi static bearing capacity formula gave reasonable results when used to compute the resistance into the target material; however, this agreement may have been merely a coincidence with the particular region of penetration velocities, depths, and penetrator widths investigated. Similar studies of penetration are discussed and referenced. (auth)

**2922** (SC-RR-66-386) MICROBIOLOGICAL STUDIES RELATING TO CLEAN ENVIRONMENTS. PART II. DEPOSITION OF NUTRIENTS TO SURFACES BY RODAC PLATES. Beakley, John Wm.; Whitfield, W. J.; Mashburn, J. C. (Sandia Corp., Albuquerque, N. Mex.). Sept. 1966. Contract AT(29-1)-789. 8p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The deposition of nutrient residues onto surfaces following impressions made with Rodac plates was observed, photographed, and quantitated. In the experiments performed, a medium residue between 20 and 50 micrograms in weight was deposited from Rodac plates onto stainless steel surfaces. Such residues were shown to be adequate to support microbial growth when such surfaces were contaminated and incubated under ideal conditions of humidity and temperature. (auth)

**2923** (TID-3737) BIBLIOGRAPHIES OF ATOMIC ENERGY LITERATURE. Issued or in Progress During the Period, August–September 1966. (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). 15p. Dep. DTI Extension Free.

A list is presented on available current bibliographies of atomic energy literature. Included also is an announcement of bibliographies in preparation, both domestic and foreign. (B.G.D.)

**2924** (TID-5001(6th Rev.)) SUBJECT HEADINGS USED BY THE USAEC DIVISION OF TECHNICAL INFORMATION. Upchurch, Robert E. (ed) (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). Nov. 1966. 333p. Dep. CFSTI $7.00 cy, $1.50 mn.

A list is given of all subject headings and associated cross references used in the preparation of subject indexes for Nuclear Science Abstracts. Classification of uranium deposits, geographic and geologic subject headings, isotope synonyms, list of elements, and standarized subheadings are also included. (B.G.D.)

**2925** (TID-22643) MECHANIZATION OF THE USAEC LIBRARY. I. LEGISLATIVE INFORMATION. Lebowitz, A. I. (Division of Technical Information (AEC), Washington, D. C.). Nov. 1966. 33p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The development of a computerized file for legislative information at the USAEC library is described. (B.G.D.)

**2926** (Y-1557) POST AUDITING MACHINE TOOL INVESTMENTS. Williams, J. L.; Christman, A. M. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). Oct. 31, 1966. Contract W-7405-eng-26. 13p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Ten tape-controlled machine tool investments were subjected to a post-audit review. The average rate of return was found to be 27%, with individual investments varying from 1.5 to 57%. The data collected during the review indicate that the most important factors in a successful tape-controlled machine investment are savings in time per part and extent of utilization. (F.S.)

**2927** PRODUCTION AND UTILIZATION FACILITY OPERATOR LICENSING. Cramer, E. N. Nucl. Safety, 7: 297-301 (Spring 1966).

Current practices in the licensing of Reactor Operators and Senior Reactor Operators are discussed. Presented in tabular form by reactor type are the numbers of operator licenses granted to date, thus indicating the general trends of operator replacement for existing low-power reactors and of new operators for new power-reactor startups. A licensing guide has been published by the AEC for use by prospective reactor operators. The first examinations at licensed fuel-reprocessing plants have been given. (auth)

**2928** ACTION ON REACTOR PROJECTS UNDERGOING REGULATORY REVIEW. Blakely, J. P. Nucl. Safety, 7: 385-95 (Spring 1966).

Recent regulatory actions relating to several power and experimental reactors are summarized and their safety characteristics are discussed. Information is included on reported difficulties or unusual occurrences. (H.D.R.)

**2929** THE ENCYCLOPEDIA OF X-RAYS AND GAMMA RAYS. Clark, George L. (ed.). [Reinhold Encyclopedia Series]. New York, Reinhold Publishing Corp., 1963. 1175p. $35.00.

Included among the many topics discussed are nuclear and nuclear-related terms such as atomistics, nuclear materials and reactors, space, missiles, aeronautics, and astrophysics. (M.O.W.)

**2930** NEWNES CONCISE ENCYCLOPAEDIA OF NUCLEAR ENERGY. Barnes, D. E.; Batchelor, R.; Maddock, A. G.; Smedley, J. A.; Taylor, Denis (eds.). London, George Newnes Ltd., 1962. 896p.

Information is included on theory, techniques, and applications of nuclear science. In addition to now well accepted definitions by nuclear scientists, lengthy discussions are also included. (M.O.W.)

**2931** HERBSTTAGUNG DER OESTERREICHISCHEN PHYSIKALISCHEN GESELLSCHAFT IN VIENNA, OKTOBER 11–14, 1965. (Papers Presented at the Fall Meeting of the Austrian Physical Society in Vienna, October 11–14, 1965). Acta Phys. Austr., 23: 1-413(1966). (CONF-651079).

The 60 papers presented at the fall meeting of the Austrian Physical Society are compiled. Separate abstracts were prepared for 50 of the papers. (J.S.R.)

*For abstracts of individual papers see: 1261, 1432, 1528, 1582–1589, 1681–1685, 1909, 2018–2021, 2289, 2290, 2377, 2406, 2434, 2435, 2554, 2587, 2588, 2602, 2603, 2671–2675, 2725–2730, 2759–2764, and 2876.*